EFFECT OF NITROGEN AND BORON ON GROWTH AND YIELD OF CHICKPEA (*Cicer arietinum* L.)

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CERTIFICATE

This is to certify that the thesis entitled, **“EFFECT OF NITROGEN AND BORON ON GROWTH AND YIELD OF CHICKPEA (*Cicer arietinum* L.)”** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN SOIL SCIENCE**, embodies the result of a piece of bonfide research work carried out by **MD. ABDUS SABUR, Registration No.13-05278** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

Dated:

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Place: Dhaka, Bangladesh

Dedicated to

My

Beloved Parents

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The author

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ABSTRACT

An experiment was carried out at the experimental field of Sher-e- Bangla Agricultural University(SAU), Sher-e-Bangla nagar, Dhaka-1207 during the period from November 2018 to April 2019. A set experiment was conducted of two different factors *viz*. Factor A: Nitrogen fertilizerlevel-3; i) N_0 = No nitrogen (Control) ii) N_1 = 25 kg ha^{-1} and iii) N_2 = 35 kg ha^{-1} and factor B: Boron fertilizer level-3; i) B_0 = No Boron (Control) ii) B_1 = 1.0 kg ha^{-1} and iii) B_2 = 1.5 kg ha^{-1}. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replication. The data on plant growth characters, yield contributing characters and harvest index were analyzed using analytical computer software program statistix-10. The mean differences among the treatments were compared by least significant difference test at 5% level of significance.

Experimental results revealed that application of nitrogen in 25 kg ha^{-1} (N_1)showed best performance in terms of higher yield and yield contributing characters viz.number of branch plant^{-1}(24.38), pod length(1.91cm), effective pod plant^{-1}(39.04), pod plant^{-1}(45.35), seed pod^{-1}(1.90), 1000-grain weight(151.64 g), grain yield(2.14 t ha^{-1}) and straw yield(2.31t ha^{-1}). whereas the lowest results were recoreded in without nitrogen (N_0). 1.5 kg ha^{-1} (B_2) boron application showed higher results on branch plant^{-1}(25.17), height pod length(1.75cm), effective pod plant^{-1}(40.96), pod plant^{-1}(47.03), seed pod^{-1}(1.93), 1000-grain weight^{1}(153.45g), grain yield(2.19 t ha^{-1}) and straw yield(2.37 t ha^{-1})over no boron application (B_0). The finding of present research work suggest that application of nitrogen in 25 kg ha^{-1} (N_1)and 1.5 kg ha^{-1} (B_2) boron application can be practices to chickpea cultivation. Among the interactions N_1B_2demonstrated the best performance considering branch plant^{-1}(25.17), branch plant^{-1}(26.37), pod length(2.02cm), effective pod plant^{-1}(44.66), pod plant^{-1}(50.36), seed pod^{-1}(2.05), 1000-grain weight(158.31g), grain yield(2.37 t ha^{-1}) and straw yield(2.51 t ha^{-1})can be for up lifting grain yield of chickpeain the salt Bangladesh.

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ABBREVIATIONS AND ACRONYMS

AEZ = Agro-Ecological Zone

Agric=Agricultural

BBS = Bangladesh Bureau of Statistics

BCSIR = Bangladesh Council of Scientific and Industrial Research

cm = Centimeter

CV % = Percent Coefficient of Variation

DMRT = Duncan's Multiple Range Test

et al., = And others

e.g. = exempli gratia (L), for example

etc. = Etcetera

FAO = Food and Agriculture Organization

g = Gram (s)

i.e. = id est (L), that is

Kg = Kilogram (s)

LSD = Least Significant Difference

m^2 = Meter squares

ml = Millilitre M.S. = Master of Science

No. = Number

SAU = Sher-e-Bangla Agricultural University

var. = Variety

O^C = Degree Celceous

% = Percentage

GM = Geometric mean

mg = Milligram

P = Phosphorus

K = Potassium

Ca = Calcium

μg = Microgram

USA = United States of America

WHO = World Health Organization Journal

J= Journal

R=Research

CHAPTER 1

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is one of the most important grain legumes as it ranks third in the world after dry bean (*Phaseolus vulgaris* L.) and field pea (*Pisum sativum* L.). Today, about 15 percent of the world's total pulse productions belong to this crop (FAO, 2010). Chickpea (*Cicer arietinum* L.), commonly known as gram, is one of the major pulse crops grown in Bangladesh. It stands 4th in respect of area (13,095 ha) and production (9,630 metric tons). (BBS, 2011). Nutritionally, Chickpea is an important source of protein in the diets of the poor, and is particularly important in vegetarian diets and is an important substitute for animal protein. It is mostly consumed in the form of processed whole seed (boiled, roasted, fried, steamed, etc.), dal and as dal flour. It is used in preparing snacks, sweets and condiments. Fresh green seeds are also consumed as a green vegetable. It is an excellent source of protein (18-22%), carbohydrates (52-70%), fat (4-10%), minerals (calcium, phosphorus, iron etc). It is also rich in minerals and vitamins. Best of the fiber in chickpeas is insoluble fiber, which is great for digestive health. Individuals who eat them typically have better blood sugar regulation since chickpeas are so high in fiber and protein. It is an excellent animal feed and its stover has good forage value (Prasad 2012).In Bangladesh, per capita net availability of pulses is 32.9 g day^{-1} (Anonymous 2013) although the World Health Organization (WHO) recommends at least 80 g capita^{-1}. This low availability of pulses causes protein malnutrition. So, there is a great need to ensure nutritional security of ever burgeoning population. There is a big gap between demand and supply of pulses and this can be overcome by increasing the productivity of pulses. Diversified domestic, industrial and other uses of chickpea and its ability to grow better with low inputs under abrasive edaphic factors and arid environments make it an important component of the cropping system of subsistence farmers in the Indian subcontinent (Verma *et al* 2013).According to the FAO (2013) yield of chickpea in Bangladesh is miserably low (761 kg ha^{-1}) as compared to that of other countries like India (833 kg ha^{-1}), Myanmar (1,106 kg ha^{-1}), Israel (1813 kg ha^{-1}), Russian Federation (2,400 kg ha^{-1}), Kazakhstan (3,000 kg ha^{-1}) and China (6,000 kg ha^{-1}). Such low yield, however, is not an indication of low yielding potentiality of this crop, but may be attributed to a number of reasons, viz., Unavailability of quality seeds of high yielding varieties, delayed sowing after the harvest of chickpea, non judicial supplementary foliar spray, disease and insect infestation. Yield gap can be abridged by adopting the advanced variety and optimum supplementary foliar spray. In the current scenario, sustainability of agriculture has become a major issue of global concern as the intensive use of chemical inputs show adverse impact on the environment and the soil fertility (Laranjo *et al* 2014, Verma *et al* 2014). The beneficial effect of chickpea in improving soil health and sustaining productivity has been realized since long. Adoption of different crop production strategies such as crop diversification, inclusion of leguminous crops in rotation, intercropping, mixed cropping and integrated nutrient management (INM).Leguminous crops have a unique property of maintaining and restoring soil fertility as well as conserving and improving physical properties of soil by virtue of their deep root system which enables them to efficiently utilize applied as well as residual soil nutrients (Das *et al* 2013).

Nitrogen (N) deficiency is frequently a major limiting factor for high yielding crops all over the world (Namvar *et al*., 2011). The supply of N to the plant will influence the abunt of protein, amino acids, protoplasm and chlorophyll formed. Consequently, it influences cell size, leaf area and photosynthetic activity (Alam and Haider, 2006). Therefore, adequate supply of N is necessary to achieve high yield potential in crops. In general, N deficiency causes a reduction in growth rate, general chlorosis, often accompanied by early senescence of older leaves, and reduced yield (Kibe *et al*., 2008;). Nitrogen fixation in chickpea ranges from 10 to 176 kg ha^{-1} $season^{-1}$, depending on method of cultivation, cultivar, presence of appropriate rhizobia and favorable environment at variable (Bcek *et al.*, 1991). There are evident that nitrogen application becomes helpful to increase the seed yield (Chaudhari *et al.*, 1998). To produce one unit of seeds, chickpea needs as much as three times more nitrogen than that needed by cereals like rice. Chickpea needs much more nitrogen at the reproductive stage than it does in the vegetative stage

Bharti *et al.* (2002) reported that mean seed yield of chickpea increased with the application of boron @ 2.5 kg/ha. Islam (2005) observed that seed yield of chickpea (cv. BARI Chola 5) increased significantly due to application of 1 to 1.5 kg B ha^{-1}. In these contexts, application of boron and molybdenum in addition to essential major elements along with a maintenance dose of cowdung has gaining practical significance for boosting up the yield of chickpea. Boron (B), an essential micronutrient, is known to participate in the nitrate reduction system of nitrogen metabolism in higher plants (Nicholas, 1961). The application of B has a great influence on the growth and development of chickpea. B is indispensable for a variety of plant species especially legumes forming root nodules because it is directly involved in the nitrogen fixing enzyme nitrogenase and nitrogen reduction enzyme nitrate reductase. The essentially of.;[Boron for the growth and development of plants were thus confirmed (Arnon and Stout 1939) and the involvements of this element in nitrate reducing process were already well established. Thus, Boron has taken an important place in the list of trace elements essential for plant growth and its use as a fertilizer has been widely recognized, especially in the pulse crop cultivation. Boron is one of the most important micronutrients for crops. B deficiency causes loss of membrane integrity and cell wall stability flower drop, subsequently poor podding of chickpeas (Srivastava *et al.,* 1997) and poor yields. Boron may cause yield losses up to 100%, it is estimated that each ton of chickpea grain removes 35 g of B from the soil (Ahlawat *et al.,* 2007). The availability of B decreases when the pH is higher than 6.5-7.0, unfavourable weather conditions (drought, high precipitation) and soil conditions (B leaching, calcareous soils: B fixation) (Sims, 2000). Chickpea while grown in sandy soil with low organic matter and boron gave poor yield (Srivastava *et al.,* 1997). In comparison with others crops, the response of the crop to the application of B is higher in chickpea than in some cereals (Wankhade*et al.,* 1996). Ahlawat*et al.* (2007) reported that soil having less than 0.3 mg B kg^{-1} is deficit for such nutrient and to be corrected by applying boron. Seed yield of chickpea increased with the application of boron @ 1.5-2.5 kg ha^{-1} (Shil *et al.,* 2007). The application of boron resulted in a higher production of dry matter which translocated to the seeds resulted in higher yield.

Keeping in view the above facts, there is a great need to increase the productivity of chickpea to meet the nutritional requirement of the growing population. Conjuctive use of nitrogen and boron can play an important role in improving the chickpea productivity in sustainable manner.

The present investigation was, therefore, undertaken with following objectives:

1. To find out the effect of N and B on growth and yield of Chickpea
2. To determined the optimum doses of N and B for higher yield of Chickpea
3. To observed the interaction effect of N and B application on growth and yield of Chickpea

CHAPTER 2

REVIEW OF LITERATURE

Chickpea (*Cicer arietinum* L.) is one of the most important grain legumes as it ranks third in the world after dry bean (*Phaseolus vulgaris* L.) and field pea (*Pisum sativum* L.). The crop has traditionally less attention by the researchers on various aspects because normally it grows without or management practices. based on this, a very few research work related to application of important nutrient such as nitrogen, boron and their effect on growth and yield of chickpea have been carried out in our country. Nitrogen and boron play an important role in improving chickpea growth and yield. However, there is evidence that the yield of chickpea can be increased substantially by using fertilizers (Katare *et al*., 1984). Some of the important and informative works and research findings related to the variety, nitrogen and boron so far been done at home and abroad have been reviewed in this chapter under the following headings –

2.1 Effect of nitrogen on chickpea

The response of chickpeas to nitrogen application is variable. They are estimated to fix from 1-141 kg N ha^{-1} depending on the method of measurement and the cultivar used (Rupela and Saxena, 1987). Several workers have reported that the application of 15-25 kg N ha^{-1} as a starter dose was useful in soils with low available soil nitrogen (Chowdhury *et al*., 1972; Saxena, 1987; Subba Rao, 1988; Roy and Singh, 1989; Thakur *et al.*, 1989). Application of 30 kg N ha^{-1} 30 days after sowing (DAS) significantly increased total dry matter (Hernandez and Hill, 1984). McKenzie *et al.* (1994) reported a 14 % increase in dry matter and seed yield 5 % increase in mean seed weight and an 8 % increase protein content with 50 kg N ha^{-1}. All this supports early work by AlIos and Bartholomew (1959), who reported that soybeans (Glycine max) and other small seeded legumes are only able to fix about one-half to three quarters of their nitrogen requirements. However, Saxena (1980) has reported that although nodulation is not adversely affected and early crop growth is slightly improved there is usually no advantage in final seed yield. A reduction in nodule biomass in chickpea with applied nitrogen has been reported by Saxena and Sheldrake (1980) and Rupela and Saxena (1987). Saxena and Sheldrake (1980) and Saxena (1987) reported that applying high rates of nitrogen (up to 100 kg ha^{-1}) did not significantly increase yield when compared to a crop with actively nodulated plants. In areas of very poor or no inoculation application of up to 120 kg N ha^{-1} hasgiven yield increases. However, with higher rates a split application (half each at sowing and flowering) was found to be better than a single one (Saxena, 1980) .• Because nitrogen is important in seed growth and thus yield, an application of nitrogen fertilizer at flowering has given substantial increases in yield. This may be because photosynthate otherwise preempted by the nodules is made available for seed development (Lawn and Brun, 1974; Hardwick, 1988). Considering the contradictory information available on the nitrogen requirements of chickpeas, it would appear that the necessity, amount and time of nitrogen application for a chickpea crop depends on the nutrient availability and the Rhizobial status of the site in question.

Nitrogen (N) deficiency is frequently a major limiting factor for high yielding crops all over the world (Salvagiotti *et al.,* 2008; Namvar *et al.,* 2011). The most important role of N in the plant is its presence in the structure of protein and nucleic acids which are the most important building and information substances of every cell. In addition, N is also found in chlorophyll that enables the plant to transfer energy from sunlight by photosynthesis. Thus, the supply of N to the plant will influence the amount of protein, amino acids, protoplasm and chlorophyll formed. Consequently, it influences cell size, leaf area and photosynthetic activity (Kibe *et al.,* 2006; Walley *et al.,* 2005; Alam, Haider, 2006; Caliskan *et al.,* 2008; Salvagiotti *et al.,* 2008). Therefore, adequate supply of N is necessary to achieve high yield potential in crops. In general, N deficiency causes a reduction in growth rate, general chlorosis, often accompanied by early senescence of older leaves, and reduced yield (Caliskan *et al.,* 2008; Erman *et al*., 2011). Mckenzie and Hill (1995) studied the effects of two levels of N applications (0 and 50 kg N ha^{-1}) on chickpea and reported that the increase of N rate from 0 to 50 kg N ha^{-1} significantly enhanced seed and dry matter yield, harvest index, number of pods per plant and 1 000 seed weight. Walley *et al.* (2005) investigated chickpea response to starter N (0, 15, 30 and 45 kg N ha^{-1}) and stated that the application of 45 kg N ha^{-1}enhanced seed yield by as much as 221 kg ha^{-1}over control. Alam and Haider (2006) studied the effects of N fertilizer on growth attributes of barley and found that total dry matter (TDM), leaf area index (LAI), crop growth rate (CGR) and net assimilation rate (NAR) increased due to N fertilization. Kibe *et al.* (2006) in wheat and Yasari and Patwardhan (2006) in rapeseed concluded the same results about these growth indices. Amany (2007) reported that urea foliar application had a significant impact on plant height, number of branches, pods and seeds per plant, 1 000 seed weight, TDM, seed yield and harvest index in chickpea.Albayrak *et al.* (2006) studied the effects of inoculation with Rh. leguminosarum on seed yield and yield components of common vetch (Vicia sativa L.) and observed that inoculated common vetchcultivars gave higher TDM (8.5%), seed yield (7.6%), straw yield (10.4%), pod length (25.5%), number of seeds per pod (16.2%), number of pods per plant (28.4%), main stem length (3.5%) and 1000 seed weight (5.5%) compared to noninoculated cultivars.N1 and N2 treatments increased the biomass yield of chick pea at by 33 and 36 % over the control (N0) respectively. The corresponding increases in grain yield were 32 and 36 % over the control respectively. However, there was no significant difference between N1 and N2 treatments in their effect on biomass and grain yields of chickpea. The increase in biomass and grain yield of chickpea shows that low level soil N in the site. This is in line with Umrai (1995) who reported that in deficient soils, application of nitrogen fertilizer to crops will bring considerable increase in the productivity. The grain yield increase found in this study was similar to that reported by Namvar*et al.* (2011) who have found only 36 % increase in grain yield of Desi type chickpea grown in silty-loam soil with the application of 46 kg N ha^{-1}in Iran.

An experiment was conducted by Lemma *et al.* (2013) to determine optimum N fertilizer rates for chickpea production. A factorial experiment consisting of three levels (0, 11.5 and 23 kg ha^{-1}) of N. Results revealed that both N have significantly affected nodulation capacities, yield and yield components of chickpea in both locations. N applied at 11.5 and 23 kg ha^{-1}increased the grain yield of chickpea by 32 and 36 % over the control respectively. The corresponding increases in Taba were 61 and 40 % over the control respectively. Significantly higher yield was obtained in Taba than in Halaba irrespective of treatments. This implies that the former location is more favorable for chickpea production than the later. In conclusion, chickpea responds significantly to N and P fertilizers in both locations suggesting low levels of soil N and P. Biological and economic optimum yields of chickpea were obtained from N: P applied at 11.5: 20 and 11.5: 10 kg ha^{-1}. Verma*et al.* (2009) reported that that physiological traits and productivity of chickpea in relation to urea and genotype and reported that 25 k ha^{-1} urea at flowering and pod development stage resulted in higher plant height (47.7 cm) that control.

Venkatesh and Basu (2012) reported that the branching of chickpea enhanced significantly due to soil application of urea and DAP and the highest branches $plant^{-1}$ (6.93) was recorded with urea spray at 75 DAS which was statistically at par with DAP spray at 75 DAS but significantly higher over control and water spray and urea spray at 105 DAS.

Namvar *et al*. (2011) suggestsd that application of 75 and 100 kg urea ha^{-1} gave the highest CGR in inoculated (35.06% increase over control) and non-inoculated (31.33% increase over control) chickpea plants, respectively. The lowest CGR was recorded in non-fertilized and non-inoculated plants. Higher CGR may be due to higher production of dry matter owing to greater LAI and higher light in-terception (Zajac *et al*., 2005; Yasari and Patwardhan, 2006).

Aktar (2013) stated that statistically significant variation was recorded for relative growth rate (RGR) of chickpea at 20-40 DAS, 40-60 DAS, 60-80 DAS and 80-100 DAS for the application of prilled urea and urea super granules. At 80-100 DAS, the highest RGR was obtained from USG placed at 20 cm distance (0.025 g g-1 day^{-1}), while the lowest RGR was recorded from USG placed at 40 cm distance (0.012 g g^{-1} day).

Rawsthorne *et al.* (1985) reported that nitrate fed chickpea plants partitioned more dry matter into the branches and leaves during early vegetative growth compared to those dependent on nitrogen fixation. After anthesis, proportionately more dry matter and nitrogen is partitioned into pod wall development and chickpea up to 60% of all the dry matter accumulated after anthesis is allocated into the seed (Khanna-Chopra and Sinha, 1987).

Duan *et al.* (2014) reported that the contribution of post-anthesis assimilates to grains under different N rates ranged from 58.5% to 80.1%, with the higher ones being obtained at 150 and 180 kg ha^{-1}. Taken together, N rates of 150 and 180 kg N ha-1 were most effective in promoting post-anthesis assimilates and dry matter accumulation in wheat grains and ultimately the grain yield.

Kulsum *et al.* (2007) stated that the performance of chickpea under various levels of nitrogen at the Bangbandhu Sheikh Mujibur Rahman Agricultural University during March to June 2002. the differences in TDM between the varieties due to fertilizer N application were less conspicuous but over the time the differences widened. The treatment with 80 kg N ha^{-1}was found superior to other treatments in accumulation of DM in these components. Leaf and stem dry weight continued to increase until mature stage then decreased irrespective of N treatments. Decreasing leaf and stem dry weight may be due to remobilization of assimilates towards grain.

Surendar *et al.* (2013) reported that the treatmental combination (N 25 kg ha-1+ Urea 2% + BR 0.1 ppm) caused more than 50 percent improvement in setting of pods in blackgram. Treatment combination (N 25 kg ha-1+ BR 0.1 ppm + Urea 2%) was found to be the most effective treatment in improving the grain yield by 27 percent over control.

Roy *et al.* (2016) reported that maximum seeds pod (1.67) was found from supplemental irrigation along with aqueous N before flowering, whereas the minimum (1.51) was observed from control treatment in pigeonpea.

Roy *et al.* (2016) reported that maximum 1000-seed weight in chickpea (274.00 g) was recorded from supplemental irrigation along with aqueous N before flowering; whereas the minimum (234.89 g) was found from control treatment.

An experiment was conducted by Abbasi et al. (2013) with nitrogen rates at four levels (0, 25, 50 and 75 kg urea ha^{-1}). The result revealed that 100 grains weights were significantly affected by nitrogen rates and seed inoculation in chickpea varieties.

Shrivastava and Shrivastava (1994) reported that chickpea was sprayed at 50% flowering with water, 2% urea, potassium sulphate and no spray. Foliar application of 2% urea gave the highest seed yield of 1.70 t/ha over control (0.66 t ha^{-1}). Ravi *et al.* (1998) reported that foliar application of 2% urea solution at flowering increased the grain yield by 22.9%over control.

Bahr (2007) conducted a field experiment in private farm at Al Beheira Governorate, Egypt to study the effect four urea foliar application treatments 1% urea sprayed at flowering, at pod set, pod filling and (control) unsprayed of chickpea. Treatments of 1% urea foliar application at pod filling gave the highest seed yield (1461kg fed^{-1}) whereas lowest seed yield (633kg fed^{-1}) in control.

Gagandeep *et al.* (2015) reported that an increase in seed yield/plant was recorded following mineral nutrients application and maximum increase was observed with 2% urea application which was 1.66 (PAU 881) and 1.77 (AL 201) fold over controls followed by 1% urea (1.45 fold in PAU 881 and 1.65 fold in AL 201). The improvement in leaf characteristics (LA and LAI) as observed in their study might have contributed towards enhanced production of assimilates through improved photosynthetic efficiency.

2.2 Effect of boron on chickpea

An experiment was conducted by Quddus *et al.* (2013) at Madaripur and Gazipur during rabi (winter) season of 2012-13 and 2013-14 to determine the optimum dose of B for different varieties of chickpea (Cicerarietinum L.). There were 12 treatment combinations comprising three varieties (BARI Chola-5, BARI Chola-8 and BARI Chola-9) and four levels of boron (0, 1, 1.5 and 2 kg ha-1) along with a blanket dose of N_{20} P_{20} K_{25} Zn_2 kg ha^{-1}. Boron was applied as H3BO3. Results showed BARI Chola-9 with 1.5 kg B ha-1 produced the highest seed yield of 1338 kg ha1 at Madaripur and 2218 kg ha^{-1} at Gazipur. Nodulation, nitrogen (N) and protein contents were also found highest for the same variety and B treatment. The other two varieties (BARI Chola-5 and BARI Chola-8) also performed higher yield in the plot receiving 1.5 kg B ha-1 compared to 1 kg B ha-1 or 2 kg B ha-1 at both locations. The results suggest that BARI Chola-9 and 1.5 kg B ha-1 along with N20P20K25S10Zn2 kg ha-1 could be used for achieving higher yield of chickpea in calcareous and terrace soils of Bangladesh.

Alam *et. al.* (2014) carried out to study the yield of chickpea as affected by boron application. Five varieties of chickpea namely BARI Chola-5, BARI Chola-6, BARI Chola-7, BARI Chola-8 and BARI Chola-9 and four levels of boron (0, 1, 2, 3 kg B ha^{-1}) were used in this experiment. A Randomized Complete Block Design was used for the experiment with three replications. Variety had significant effects on yield and its components of chickpea. BARI Chola-8 showed better performance and produced the highest seed yield (1.74) as compared to other varieties used in the study. Application of boron significantly improved yield and yield attributes of chickpea. The highest seed yield (1.70 t ha-1) was obtained at 3 kg B ha-1 as compared to other levels of boron application. Results revealed that BARI Chola-8 integrated with 3 kg B ha-1 was found to be the best treatment for higher yield of chickpea.

Rawashdeh and Sala (2015) reported that plant height increased significantly due to foliar application of micronutrient (Fe, B, Fe+B) at different stages of chickpea. At 90 DAS also the treatment potassium nitrate @ 2 percent + boric acid @ 50 ppm + zinc sulphate @ 1 percent at 30 DAS and 60 DAS recorded higher plant height (48.83 cm) which was 28.50 percent greater over the control (38.00 cm).

Alam *et al.* (2017) stated that the highest number of primary branches plant^{-1} (4.93) and secondary branches plant^{-1} (23.13) was observed at 3 kg B ha^{-1} and the lowest one (4.24) was observed at control treatment (0 kg B ha^{-1}) in chickpea.

Gowthami and Rao (2014) carried out a field experiment at the Agricultural College Farm, Agricultural College, Bapatla to study the effect of foliar application of potassium, boron and zinc on growth and yield of soybean. At 90 DAS the treatment potassium nitrate @ 2 per cent + boric acid @ 50 ppm + zinc sulphate @ 1 per cent at recorded higher number of branches (9.63) which was 30.13% higher over control (7.40). Role of the nutrients in various physiological and biological processes contributing to the proper growth of plants to their maximum potential might be the reason for higher number of branches (Sawan et al., 2008).

Valenciano *et al*. (2010) studied the response of chickpea to the foliar applications of Zn, B and Mo was studied in pot experiments with natural conditions and acidic soils. There were low significant interactions between Zn and B for total DW, the highest total DW value was obtained with 4 mg Zn+ 2mg B per pot (6.85 g plant-1) and the lowest was obtained with 0 mg Zn+ 2 mg B per pot (4.98 g plant^{-1}).

Wasaya *et al.* (2017) reported that maximum CGR was observed at 90 DAS, after which it started to decline in maize with higher value under soil applied B and Zn mixture. However, improvement in CGR was observed with application of B and Zn with higher value under soil application, which was at par with foliarly applied Zn and B mixture.

Tekale *et al.* (2009) reported that productivity of pigeon pea was not only dependent on accumulation of total amount of dry matter but its effective partitioning into economic sink seems to be key to increase the yield. The leaf, stem, root and total dry matter plant-1 varied significantly at 125 and 180 DAS. Dry matter accumulation in leaf, stem, root and total dry matter was maximum in IAA + B + Zn at both FL and PI stages treatment. Dry matter accumulation in pods was the highest in IAA + B + Zn at both flowering and Pod initiation stages treatment (46%) as compared to control (34%).

Chatterjee and Bandyopadhyay (2015) reported that spraying of boron at 4 weeks of planting recorded increased the number of pods (24.89), that is 26% higher number of pods and 13% greater pod yield/plant over the control in cowpea. Foliar spray of boron at 4 weeks and 6 weeks and only 6 weeks also produced 24% and 18% greater number of pods and 11% and 7% higher pod yield/plant over the control respectively.

Shinde *et al. (*2017) reported that among the different treatments ZnSO4 2g/kg of seed+ Boron 2g/kg of seed+ ammonium molybdate 2 g/kg of seed+ FeSO4 2g/kg of seed recorded significantly higher number of pods (94.5) plant-1 in chickpea compared to all other treatments and control (84.4).

Ali and Mishra (2001) conducted an experiment during the rabi seasons of 2003-04 and 2004-05 at Allahabad, Uttar Pradesh, to evaluate the effect of micronutrients on growth and yield of kabuli chickpea (Cicerkabulium) var. Pragati. 0.2 % borax at 50 and 60 days after sowing resulted in higher number of seeds per pod (1.3) than control (1.1)

Schon and Blevins (1990) conducted field experiments were completed with both soil and foliar applications of B in soybean. Six split foliar applications which totaled 1.12kg B/ha in 1987 increased the number of seeds/pod.

Alam *et al.* (2017) reported that the highest number of seeds pod^{-1} (1.90) was given by BARI Chola-8 with 3 kg B ha^{-1}. The lowest number of seeds pod^{-1} (1.56) was given by BARI Chola-5 at control treatment.

Shinde *et al.* (2017) reported that significantly higher hundred seed weight of chickpea was 25.9 g was recorded by ZnSO4 2g/kg of seed+ Boron 2 g/kg of seed+ Ammonium molybdate 2 g/kg of seed+ FeSO4 2g/kg of seed compared to all other treatments and control (23.6 g). This increase in hundred seed weight might be due to role of micronutrients (boron) in pollen germination, seed development, cell division, translocation of sugar and starch from source to sink (Valenciano*et al.,* 2010).

Shruthi (2013) stated that hundred seed weight is also one of the yield contributing components however, which did not differ significantly due to higher number of seeds per plant iin soybean. Numerically higher 100 seed weight (14.93 g) was recorded in ZnSO4 @ 0.3%+ Boron @ 0.2%+ KNO3 @ 0.5% compared to control (10.77 g). Increased 100 seed weight may be due to the supplies of more nutrients in turn resulted in proper development of seed in the plant thereby increased the 100 seed weight in ZnSO4 @ 0.3% + Boron @ 0.2% + KNO3@ 0.5% compared to control.

Chatterjee and Bandyopadhyay (2015) reported that the treatment boron foliar spray with other combination produced 42% higher number of pods and 54% greater pod yield/plant in chickpea over the control. The treatment combination seed treatment with Mo and biofertilizers+ foliar spray of B at 4 weeks and 6 weeks of planting and Mo and biofertilizers+ foliar spray at 6 weeks of planting registered 41% and 36% higher number of pods and 51% and 45% greater pod yield/plant over the control respectively.

Ali and Mahmoud (2013) reported that the maximum seed yields ha–1 (2000 and 2030 kg ha–1 in first and second seasons, respectively) were found when mungbean plants sprayed with 150 ppm B and 500 ppm Zn with no significant differences between this interaction. This is to be logic since the highest values of yield components and consequently seed yield ha–1 gained with the same interaction.

Mahmoud *et al.* (2011) stated that straw and seed yield per feddan were significantly improved in fababean by applying nitrogen @ 40 kg nitrogen per faddan along with 50-100 ppm boron.

Alam *et al.* (2017) stated that highest stover yield (2.27 t ha-1) of chickpea was noticed at the highest level of boron application (3 kg B ha-1) and the lowest one (1.85 t ha-1) was in control treatment. The effect between variety and boron level failed to produce significant variation on stover yield.

CHAPTER 3
MATERIALS AND METHODS

The present investigation entitled, ""**Effect of nitrogen and boron on growth and yield of chickpea (*cicer arietinum* L.”** was carried out under field conditions during November 2018 to April 2019 at the experimental field of Sher-e-Bangla Agricultural University, Dhaka -1207. The related laboratory work was carried out in the Soil Science Laboratory of Department of Soil Science, Sher-e-Bangla Agricultural University. The details of the research work carried out, materials used and methodologies adopted in this research are described here under.

3.1 Experimental site

The farm is geographically located at $23^{0}77^{'}$ N latitude and $90^{0}35'$ E longitude at an altitude of 8.6 m above mean sea level under the Agro-ecological zone of Modhupur Tract, AEZ-28.

3.1.1 Weather during the crop growth period

The climate of the experimental site is subtropical. It receives rainfall mainly from South West monsoon (May-October) and winter season from November to February. The weather data during experimental period was collected from the Meteorological Station of Bangladesh, Sher-e Bangla Nagar, presented in Appendix II.

The maximum temperature during the crop growth period ranged from 15^{0}C to 35^{0} C with an average of 28.5^{0} C during 2018, while the minimum temperature 10^{0} C to 24^{0} C with an average 17.33^{0} C. The mean relative humidity ranged from 57 percent to 74 percent. The total rainfall received during the crop growth period was 302 mm received in 27 rainy days.

3.1.2 Soil

The soil of the research field belongs to “The Modhupur Tract”, AEZ – 28 is slightly acidic in reaction with low organic matter content. The experimental area was above flood level and sufficient sunshine with having available irrigation and drainage system during the experimental period. Soil sample from 0-15 cm depth were collected from experimental field and the soil analysis were done from Soil Resources Development Institute (SRDI), Dhaka. The experimental plot was high land having pH 5.6. The physical properties and nutritional status of soil of the experimental plot are given in Appendix III.

3.2 Planting material

The variety of BARI Chhola-9 was used in this study.The seeds were collected from the Agronomy Division of Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. The seeds were healthy, pulpy, well matured and free from mixture of other seeds, weed seeds and extraneous materials. BARI Chhola-9 is high yielding variety, plant height range 55-60 cm, it produce number of pod plant^{-1}. 55-60. Life cycle of this variety ranges from 125 to 130 days. Maximum seed yield is 2.3-2.7 t ha^{-1}. Aslo disease tolerant variety.

3.3 Treatments of the experiment

The experiment consists of two factors:

Factor A: Nitrogen fertilizer

i. N_0 = No nitrogen (Control)
ii. N_1 = 25 kg ha^{-1}
iii. N_2 = 35 kg ha^{-1}

Factor B: Boron fertilizer

i. B_0 = No Boron (Control)
ii. B_1 = 1.0 kg ha^{-1}
iii. B_2 = 1.5 kg ha^{-1}

3.4 Germination test

In germination test, BARI Chola-9 showed 85% germination in the petridish.

3.5 Field preparation

At the time of sowing, pre-sowing irrigation was applied to maintain the adequate moisture in the soil profile. The field was prepared with five ploughings, twice with disc harrow and then with tractor drawn cultivator followed by planking, to crush the clods as well as to eradicate weeds.

3.6 Fertilizer application

Triple super phosphate (TSP), Muriate of potash (MoP), gypsum, zinc sulphate and were used as a source of phosphorous and potassium at the rate of 90, 40, and 110, respectively following the Bangladesh Agricultural Research Institute (BARI) recommendation.

Urea and Boric acid were applied for the source of nitrogen and Boron as per treatment. All the fertilizers were collected from the farm of SAU.

3.7 Experimental design and layout

The experiment was laid out in a Randomized Complete block Design (RCBD) with three replications. There were total 9 treatments combination and total 27 plot. The size of the each unit plot was 8.4m^2 (3.5 m × 2.4 m). The space between two blocks & two plots were 1.2 m & 0.5 m, respectively. Row to row and plant to plant distances were 40 and 10 cm respectively.

3.8 Seed treatment

Before sowing the crop, the seed was treated with Captan @ 3 g kg^{-1} of seed treated against seed-borne diseases.

3.8 Seed sowing and spacing

Before sowing seeds were treated with Autostin to control the seed borne disease. The seeds of chickpea were sown in November 29, 2018 in solid rows in the furrows having a depth of 2-5 cm maintaining 40 cm row to row distance. Water was supplied every line before sowing of chickpea seeds. 85% of seeds were germinated on the 5th day after sowing. The sowing was carried out at 40 cm row spacing using a seed rate of 45 kg ha^{-1} with pora method of sowing.

3.10 Intercultural operations

3.10.1 Thinning and weeding

Seeds started germination of five days after sowing (DAS). Thinning was done two times; at 12 DAS and at 18 DAS to maintain optimum plant population in each plot. First weeding was done at 30 DAS (29 December, 2018) and then weeded as per necessary of the experimental plots.

3.10.2 Irrigation and mulching

During the crop period, three irrigations were applied according to the need of the crop. Mulching also done as par requirement few days after irrigation.

3.10.3 Weed control

Pre-emergence herbicide Stomp 30 EC (Pendimethalin) was applied @ 2.5 l ha^{-1} to control weeds. To keep the plots free from weeds, two hand hoeings were done at 4 and 8 weeks after sowing the crop with wheel hand hoe during the crop growth period.

3.10.4 Plant protection

Indoxacarb @ 500 ml ha^{-1} in 250 liters of water was sprayed twice during the crop period with a manually operated knapsack sprayer to keep gram caterpillar (Helicoverpa armigera) under control.

3.11 Harvesting and threshing

The harvesting of the crop was done on 19 April 2018, when the plants dried up and pods turned brown in colour. The harvested crop was tied in well labeled bundles and then threshing was done manually.

3.12 Drying, cleaning and weighing

The seeds thus collected were dried in the sun for reducing the moisture in the seeds to a constant level. The dried seeds and straw were cleaned and weighed.

3.13 Recording of data

The data were recorded from 25 DAS and continued untilthe end of recording of yield contributing characters of the characters of the crop after harvest. Dry weights of plant were collected from the inner rows leaving border rows by destructive sampling of 5 plants at different dates. The following data were recorded during the experiment.

A. Crop growth characters

i. Plant height (cm)

ii. Dry weight plant^{-1}

iii. Branches plant^{-1}(no.)

B. Yield contributing characters

i. Pod length (cm)

ii. Pod plant^{-1} (no.)

iii. Effective pod plant^{-1} (no.)

iv. Non effective pod plant^{-1} (no.)

v. Seed pod^{-1}(no.)

vi. 1000-seed weight (g)

C. Yield

i. Seed yield (t ha^{-1})

ii. Stover yield (t ha^{-1})

iii. Biological yield (t ha^{-1})

iv. Harvest index (%)

3.14 Detailed procedures of recording data

3.14.1 Plant height (cm)

The height of five randomly selected plants from each plot was measured from the ground surface up to the top of the main stem of plant. The initial observation was recorded at 25 DAS and then subsequently at 25 days interval till harvesting.

3.14.2 Dry weight plant^{-1}

Five plants were collected randomly from each plot at 25, 50, 75, 100 DAS and harvest (128 DAS). Then the plant placed in oven maintaining 70^{0}C for 72 hours for oven dry until attained a constant weight and the mean of dry weight of plant^{-1}was determined and it was expressed in gram (g).

3.14. 3 Number of branche splant^{-1}

Five representative plants from each plot were selected randomly and number of primary as well as secondary branches were counted, and then presented on plant-1 basis. These were recorded periodically at 25 days interval.

3.14.4 Pod length (cm)

Five representative pod were harvested from each plot at maturity and pod length was measured and averaged.Measurement of pod length was taken from basal calyx to apex of each pod.

3.14.5 Number of pods plant^{-1}

The number of pods from each of the ten randomly selected plants from each plot were counted at the time of harvesting. Their average value was expressed as pods plant^{-1}.

3.14.6 Effective pods plant^{-1} (no.)

Grain was considered to be effectivepod if any mature grain was present in pod. The number of total effective pod present total pod of five plant were recorded and finally averaged.

3.14.7 Non effective pods plant^{-1} (no.)

Non effective podmeans the absence of mature grain inside in pod and the number of total non effective pod present total pod of five plant were recorded and finally averaged.

3.14.8 Seed pod^{-1}(no.)

For calculating the seed pod^{-1}the twenty pods were chosen at random from each plot and their seed were counted. Their average value was represented as the number of grains pod^{-1}.

3.14.9 1000-seed weight (g)

One thousand grains were counted from the produce of each plot and their weight was expressed in grams to represent the 1000-grain weight.

3.14.10 Seed yield (t ha$^{-1)}$

After manually threshing the entire produce from net area of each plot grain yield was obtained and represented as t ha^{-1}.

3.14.11 Stover yield(t ha^{-1})

It was obtained by deducing the grain yield from biological yield of each treatment and denoted in terms of t ha^{-1}.

3.3.14.12 Biological yield(t ha^{-1})

Before threshing the total weight of harvested crop plants from the net plot area was considered as the biological yield. The recorded biological yield was expressed in t ha^{-1}. The biological yield was calculated with the following formula:

Biological yield = Grain yield + Straw yield.

3.14.13 Harvest index (%)

Harvest index was calculated from the grain yield and straw yield of chickpea for each plot and expressed in percentage.

$$\text{HI (\%)} = \frac{\text{Grain yield (t ha}^{-1})}{\text{Biological yield (t ha}^{-1})} \times 100$$

3.15 Methods for Soil Analysis

3.15.1 Particle size analysis of soil

Particle size analysis of the soil was done by hydrometer method (Bouyoucos, 1927). The textural class was determined using Marshall's Triangular Co-ordinate as designated by USDA.

3.15.2 Organic carbon (%)

Organic carbon in soil was determined by Walkley and Black's (1934) wet oxidation method. The underlying principle is to oxidize the organic carbon with an excess of 1 N $K_2Cr_2O_7$ in presence of conc. H2SO4 and to titrate the residual $K_2Cr_2O_7$ solution with 1 N $FeSO_4$ solution. The result was expressed in percentage.

3.15.3 C/N ratio

The C/N ratio was calculated from the percentage of organic carbon and total N.

3.15.4 Soil organic matter

Soil organic matter content was calculated by multiplying the percent value of organic carbon with the Van Bemmelen factor, 1.724 as described by Piper (1942).
% organic matter = % organic carbon × 1.724

3.15.5 Soil pH

The PH of the soil was determined with the help of a glass electrode pH meter using soil: water ratio being 1**:**2**.**5 (Jackson, 1973).

3.15.6 Total nitrogen (%)

Total nitrogen content in soil was determined by Kjeldahl method by digesting the soil sample with conc. H_2SO_4, 30% H_2O_2 and catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se = 10:1:0.1) followed by distillation with 40% NaOH and by titration of the distillate trapped in H_3BO_3 with 0.01 N H_2SO_4 (Black, 1965).

3.15.7 Available boron (ppm)

Available boron (B) content in the soil samples was determined by the method described by Hunter (1984). The extracting agent used was monocalcium phosphate [$CaH_4(Po_4)_2$. H_2O] solution and colour was developed by curcumin solution. The absorbance was read on spectrophotometer at 555 nm wavelengths.

3.24 Statistical analysis

The statistical analysis of recorded data for various parameters was done, according to Factorial Randomized Complete Block Design (RCBD), by using statistix-10 software program and the mean differences were adjusted by Least Significant Difference (LSD) test at 5% level of significance.

CHAPTER IV

RESULTS AND DISCUSSION

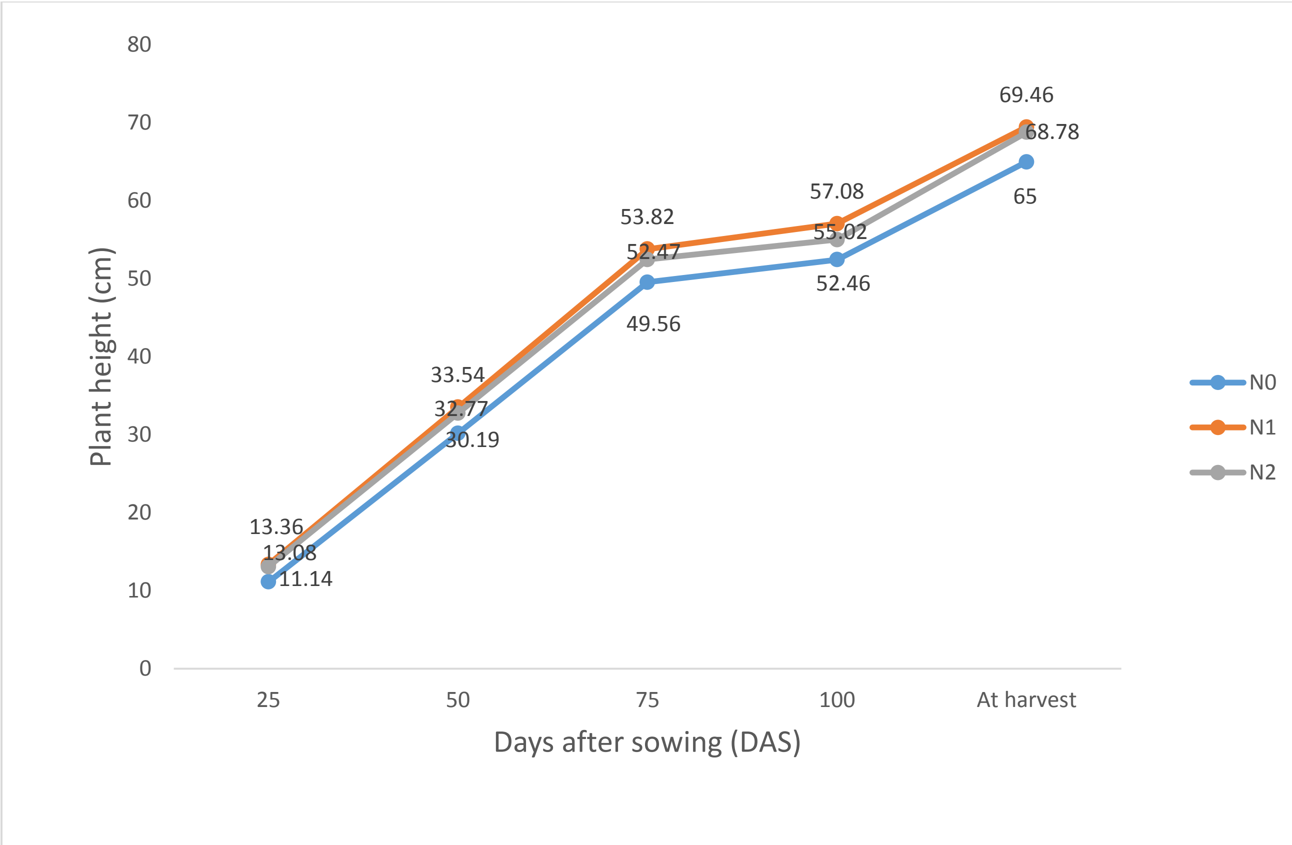
The present experiment was carried out at experimental field of Sher-e- Bangla Agricultural University(SAU), Sher-e-Bangla nagar, Dhaka-1207 during the period from November 2018 to April 2019 to investigate the ‘‘**Effect of nitrogen and boron on growth and yield of chickpea (*cicer arietinum* L.)’’** The results of the experimentanalyzedstatistically are discussed in the section through tables, figures, appendices, and other information with cause, effects and corroborative research findings of the scientists.

4.1 Crop growth parameters:

4.1.1 Plant height (cm)

Effect of nitrogen

Plant height of chickpea at different days after sowing presented in Figure 1. It is noticed from the figure that plant height significantly influenced by different dose of nitrogen. The result revealed that plant height progressively increase with increasing age of the crop. The growth rate much higher from 25 to 75 DAS. The maximum plant height (13.36, 33.54, 53.82, 57.08 and 69.46 cm) was found in 25 kg ha^{-1} (N_1) nitrogen application at 25, 50, 75, 100 DAS and at harvest, respectively which was statistically identical with 35 kg ha^{-1} (N_2)at 25 and 50 DAS and similar with 75, 100 and at harvest. The shortest plant (11.14, 30.19, 49.56 and 65.00 cm) was revealed from without nitrogen (N_0) at 25, 50, 75 DAS and at harvest, respectively which was statistically similar with 35 kg ha^{-1} (N_2) at75, 100 DAS and at harvest.

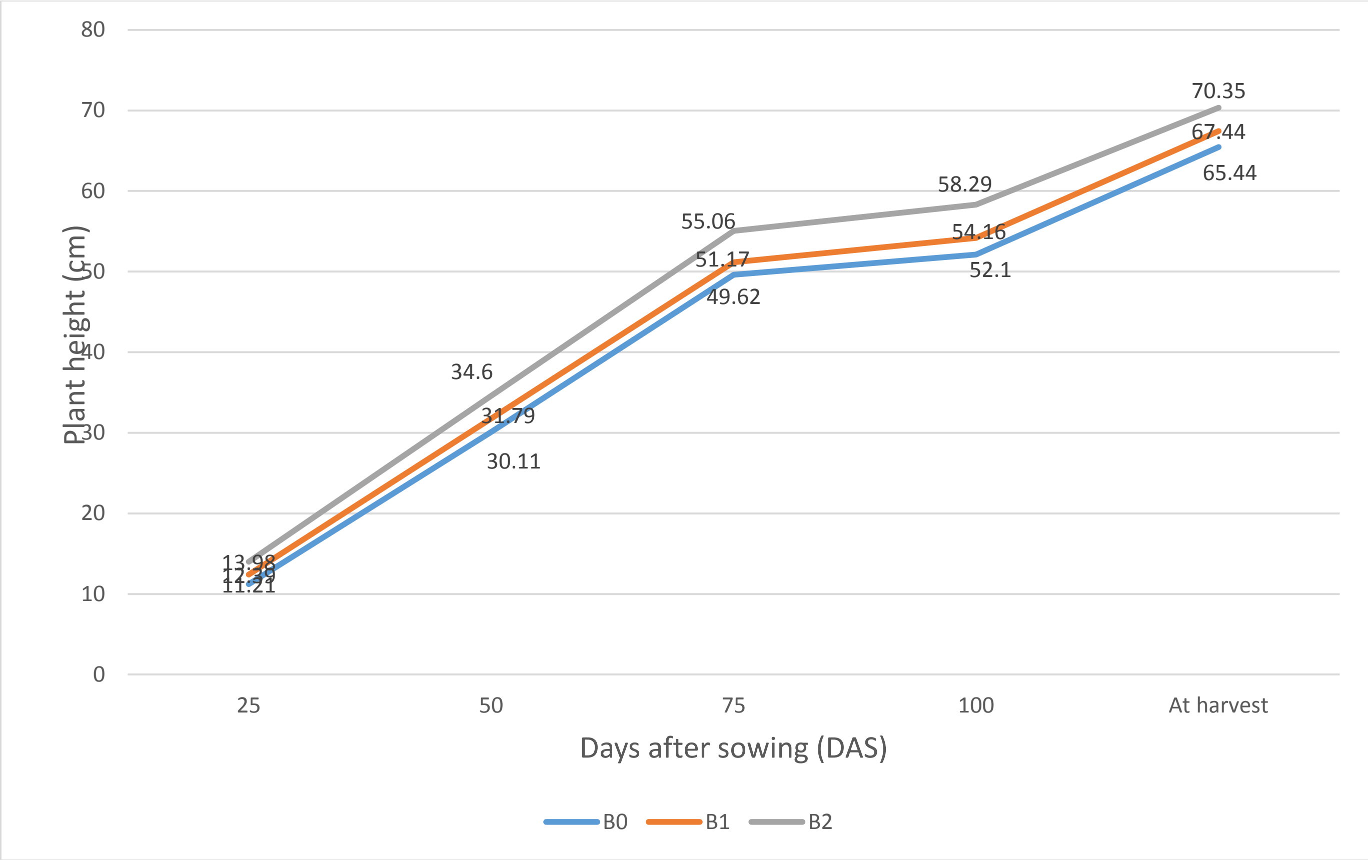


i) N_0 = No nitrogen (Control); ii) N_1 = 25 kg ha^{-1}; iii) N_2 = 35 kg ha^{-1}

Figure 1. Effect of nitrogen on plant height of chickpea at different days after sowing (SE (±) = 0.2564, 1.0326, 1.7447, 1.8522 and 1.9727 at 25, 50, 75, 100 DAS and at harvest, respectively)

Effect of boron

Plant height of chickpea at different days after sowing as influenced by boron are shown in figure 2. It is inferred that the plant height was increased gradually at harvest and the highest plant (13.98, 34.60, 55.06, 58.26 and 70.35 cm) was obtained from 1.5 kg ha^{-1} (B_2) boron application at 25, 50, 75, 100 DAS and at harvest, respectively which was statistically similar with1.0 kg ha^{-1}(B_1) at harvest. The shortest plant (11.21, 30.11, 49.62, 52.10 and 65.44 cm) was recorded at no boron application (B_0)at25, 50, 75, 100 DAS and at harvest respectively which was statistically identical with 1.0 kg ha^{-1}(B_1) at 25, 50, 75, 100 DAS and at harvest.The results showed that boron significantly influenced and increased the plant height over no boron application.



i) B_0 = No Boron (Control); ii) B_1 = 1.0 kg ha^{-1}; iii) B_2 = 1.5 kg ha^{-1}

Figure 2. Effect of boron on plant height of chickpea at different days after sowing (SE (±) = 0.2564, 1.0326, 1.7447, 1.8522 and 1.9727 at 25, 50, 75, 100 DAS and at harvest, respectively)

Interaction effect of nitrogen and boron

Significant variation was noticed on plant height at different days after sowing as influenced by interaction effect of nitrogen and boron (Table 1). The tallest plant (15.30, 37.20, 58.77, 62.47 and 72.85 cm at 25, 50, 75, 100 DAS and at harvest, respectively) was remarked on treatment combination of N_1B_2 (25 kg ha^{-1}×1.5 kg $ha^{-1)}$ whichwas statistically similar with N_2B_2 at 50 and 100 DAS, N_2B_2 at 75 DAS, all combination except N_0B_0 at harvest. The shortest plant (10.32, 29.31, 47.50, 49.97 and 62.70 cm) at 25, 50, 75, 100 DAS and at harvest, respectively) was noticed on treatment combination of N_0B_0 (without nitrogen × no boron application) which was statistically similar with N_0B_2 at 25 DAS and N_0B_1, N_0B_2, N_1B_0, N_1B_1, N_1B_2, at 50, 75 100 DAS and at harvest.

Table 1. Interaction effect of nitrogen and boron of plant height on chickpea at different days after sowing.

INTERACTION	Plant height (cm) at different days after sowing				
	25	**50**	**75**	**100**	**At harvest**
N_0B_0	10.32 h	29.31 d	47.50 c	49.97 c	62.70 c
N_0B_1	10.59 gh	29.98 cd	50.10 bc	53.10 bc	64.20 bc
N_0B_2	12.51 de	31.30 cd	51.10 bc	54.31 bc	68.10 a-c
N_1B_0	11.30 fg	30.13 cd	50.47 bc	53.37 bc	66.31 a-c
N_1B_1	13.50 bc	33.30 bc	52.23 bc	55.41 bc	69.23 a-c
N_1B_2	15.30	37.20 a	58.77 a	62.47 a	72.85 a
N_2B_0	12.02 ef	30.91 cd	51.20 bc	52.98 bc	67.33 a-c
N_2B_1	13.10 cd	32.10 b-d	55.32 ab	53.99 bc	68.91 a-c
N_2B_2	14.13 b	35.30 ab	47.50 c	58.11 ab	70.12 ab
SE(±)	**0.4440**	**1.7885**	**3.0220**	**3.2082**	**3.4168**
CV(%)	**4.34**	**6.81**	**7.12**	**7.16**	**6.18**

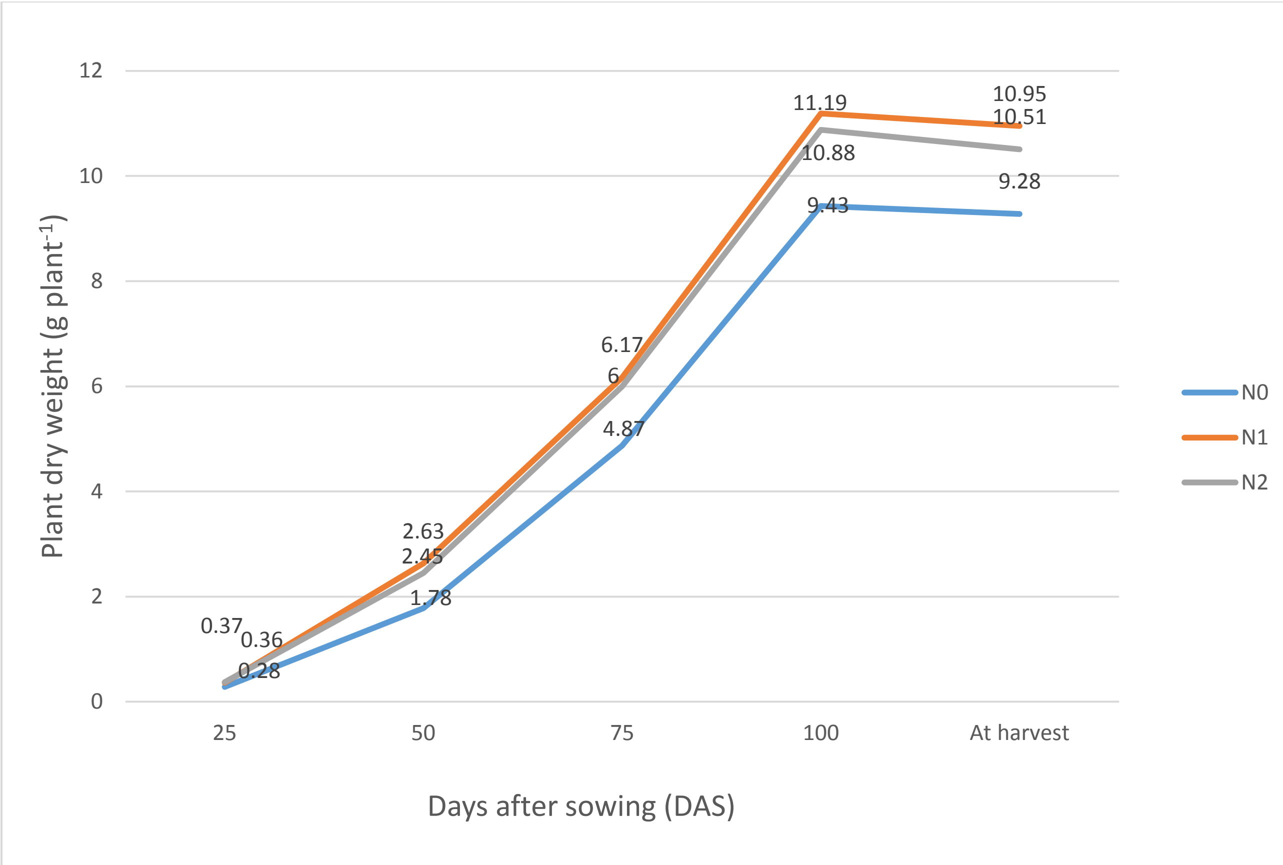
i) N_0 = No nitrogen (Control); ii) N_1 = 25 kg ha^{-1}; iii) N_2 = 35 kg ha^{-1}

i) B_0 = No Boron (Control); ii) B_1 = 1.0 kg ha^{-1}; iii) B_2 = 1.5 kg ha^{-1}

4.1.2 Plant dry weight (g plant $^{-1}$)

Effect of nitrogen

Plant dry weight of chickpea at different days after sowing presented in Figure 3. It is noticed from the figure that significant influence plant dry weight by different dose of nitrogen. The result revealed that plant dry weight progressively increase with increasing age of the crop. The growth rate much higher from 25 to 75 DAT. The maximum plant dry weight (0.37, 2.63, 6.17, 11.19 and 10.95g) was found in 25 kg ha^{-1} (N_1) at 25, 50, 75, 100 DAS and at harvest, respectively which was statistically identical with 35 kg ha^{-1} (N_2) at 25, 75 and 100 DAS and similar at harvest. The minimum plant dry weight (0.28, 1.78, 4.87, 9.43 and 9.28g) was revealed from without nitrogen (N_0) at 25, 50, 75, 100 DAS and at harvest, respectively which was statistically similar with 35 kg ha^{-1} (N_2)at harvest.

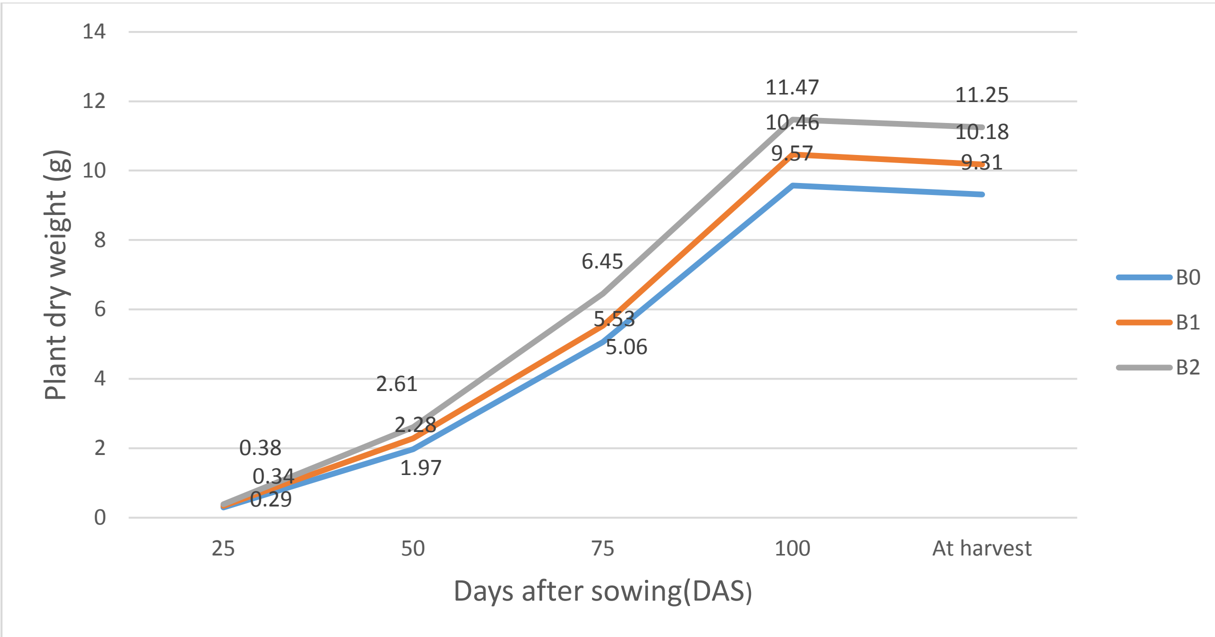


i) N_0 = No nitrogen (Control); ii) N_1 = 25 kg ha^{-1}; iii) N_2 = 35 kg ha^{-1}

Figure 3. Effect of nitrogen on plant dry weight (g) of chickpea at different days after sowing (SE (±) = 0.0221, 0.0428, 0.1506, 0.6552 and 0.6529 at 25, 50, 75, 100 DAS and at harvest respectively)

Effect of boron

Plant dry weight of chickpea at different days after sowing as influenced by boron are presented figure 4. It is observed that the highest plant dry weight (0.38, 2.61,6.45, 11.47, 11.25 g) was obtained from 1.5 kg ha^{-1} (B_2) boron application at 25, 50, 75, 100 DAS and at harvest, respectively which was statistically similar with 1.0 kg ha^{-1}(B_1) at 25, 100 DAS and at harvest . The minimum plant dry weight (0.29, 1.97, 5.06, 9.57 and 9.31 g) was recorded at without boron application (B_0) at 25, 50, 75, 100 DAS and at harvest respectively which was statistically similar with 1.0 kg ha^{-1} (B_1) at 25, 100 DAS and at harvest. The results showed that boron significantly influenced and increased the plant dry weight over no boron application.



i) B_0 = No Boron (Control); ii) B_1 = 1.0 kg ha^{-1}; iii) B_2 = 1.5 kg ha^{-1}

Figure 4. Effect of boron on plant dry weight (g) of chickpea at different days after sowing (SE (±) = 0.0221, 0.0428, 0.1506, 0.6552 and 0.6529 at 25, 50, 75, 100 DAS and at harvest respectively)

Interaction effect of nitrogen and boron

Interaction between nitrogen and boron was affected significantly on plant dry weight at all sampling dates (Table 2). The maximum plant dry weight (0.41, 2.73,6.99, 12.34 and 12.11 g) at 25, 50, 75, 100 DAS and at harvest, respectively) was remarked on treatment combination of N_1B_2 (25 kg ha^{-1}× 1.5 kg ha^{-1}) which was statistically similar with N_0B_2, N_1B_1, N_2B_0, N_2B_1,N_2B_2 at 25 DAS, N_1B_1, N_2B_2 at 50 DAS, identical at 75 DAS and N_0B_2, N_1B_0, N_1B_1, N_2B_0, N_2B_1, N_2B_2 at 100 DAS and at harvest. The minimum plant dry weight (0.23, 1.19, 4.10, 8.38 and 8.10 g $plant^{-1}$) at 25, 50, 75, 100 DAS and at harvest, respectively) was noticed on treatment combination of without nitrogen × no boron application N_0B_0 which was statistically similar with N_0B_1at 25 DAS and N_0B_1, N_0B_2, N_1B_0, N_1B_1, N_1B_2, at 100 DAS and at harvest.

Table 2. Interaction effect of nitrogen and boron on plant dry weight (g) on chickpea at different days after sowing.

INTERACTION	Plant dry weight (g) at different days after sowing				
	25	**50**	**75**	**100**	**At harvest**
N_0B_0	0.23 d	1.19 g	4.10 d	8.38 c	8.10 c
N_0B_1	0.27 cd	1.71 f	4.98 c	9.81 bc	9.64 bc
N_0B_2	0.35 a-c	2.44 d	5.55 b	10.10 a-c	10.11 a-c
N_1B_0	0.32 bc	2.55 b-d	5.61 b	10.22 a-c	10.03 a-c
N_1B_1	0.37 ab	2.62 a-c	5.91 b	11.02 ab	10.71 ab
N_1B_2	0.41 a	2.73 a	6.99 a	12.34 a	12.11 a
N_2B_0	0.33 a-c	2.19 e	5.47 bc	10.13 a-c	9.81 a-c
N_2B_1	0.38 ab	2.51 cd	5.72 b	10.55 abc	10.19 a-c
N_2B_2	0.40 ab	2.67 ab	6.81 a	11.97 ab	11.55 ab
SE(±)	**0.0383**	**0.0741**	**0.2609**	**1.1349**	**1.1309**
CV(%)	**13.80**	**3.97**	**5.62**	**13.23**	**13.51**

i) N_0 = No nitrogen (Control); ii) N_1 = 25 kg ha^{-1}; iii) N_2 = 35 kg ha^{-1}

i) B_0 = No Boron (Control); ii) B_1 = 1.0 kg ha^{-1}; iii) B_2 = 1.5 kg ha^{-1}

4.2 Yield contributing characters

4.2.1 Branches plant^{-1} (no.)

Effect of nitrogen

The data regarding the number of branches plant^{-1}(Table 3) exerted significant influence due to nitrogen. The maximum number of branch plant^{-1} (20.38) was found in 25 kg ha^{-1} (N_1 which was statistically identical with 35 kg ha^{-1} (N_2). The minimum number of branch plant^{-1}(17.60) was revealed from without nitrogen (N_0) which was statistically different with other treatment.

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Effect of boron

Number of branches plant^{-1} of chickpea at different days after sowing as influenced by boron are shown in table 4. The maximum number of branch plant^{-1}(21.17) was obtained from 1.5 kg ha^{-1}

(B_2) boron application which was statistically similar with 1.0 kg ha^{-1}(B_1). The lowest branch $plant^{-1}$(17.51) was recorded at without boron application (B_0) which was statistically similar with 1.0 kg ha^{-1} (B_1). The results showed that boron significantly influenced and increased the branch $plant^{-1}$ over no boron application.

Interaction effect of nitrogen and boron

Significant variation was noticed on branches $plant^{-1}$ at different days after sowing as influenced by interaction effect of nitrogen and boron (Table 5). The maximum number of branch $plant^{-1}$ (22.37) was remarked on treatment combination of 25 kg ha^{-1}×1.5 kg ha^{-1}(N_1B_2) which was statistically identical with N_2B_2 and similar with N_0B_2, $N_1B_1$and N_2B_1. The lowest branch $plant^{-1}$ (17.19) was found on interaction effect of without nitrogen × no boron application (N_0B_0)which was statistically similar with N_0B_1,N_0B_2, N_1B_0, N_2B_0.

Table 3. Effect of nitrogen of Branch $plant^{-1}$ (no.), Pod length (cm), Effective pod $plant^{-1}$ (no.) and Non effective pod $plant^{-1}$ (no.) on chickpea

NITROGEN	Branch $plant^{-1}$ (no.)	Pod length (cm)	Effective pod $plant^{-1}$ (no.)	Non effective pod $plant^{-1}$ (no.)
N_0	17.60 b	1.73 b	33.46 b	6.84 a
N_1	20.38 a	1.91 a	39.04 a	6.32 bc
N_2	20.03 a	1.60 c	37.83 a	6.25 c
SE(±)	**0.9542**	**0.0630**	**1.0361**	**0.3206**
CV(%)	**8.67**	**7.64**	**5.98**	**10.51**

i) N_0 = No nitrogen (Control); ii) N_1 = 25 kg ha^{-1}; iii) N_2 = 35 kg ha^{-1}

4.2.2 Pod length (cm)

Effect of nitrogen

The pod length of chickpea at different days after sowing as influenced by nitrogen are shown in Table 3. The height of pod length (1.91cm) was obtained from 25 kg N ha^{-1} (N_1) application and the lowest pod length (1.60cm) was recorded at without nitrogen (N_0).

Effect of boron

The data on pod length (Table 4) showed significant influence due to boron. The heighest pod length (1.75cm) was found in 1.5 kg ha^{-1} (B_2) boron which was statistically similar with 35 kg N ha-^{1} (N_2). The minimum pod length (1.64cm) was produced without boron application (B_0) which was statistically different with other treatment.

Interaction effect of nitrogen and boron

Significant variation was noticed on pod lengthat different days after sowing as influenced by interaction effect of nitrogen and boron (Table 5). The heighest pod length (2.02cm) was produced by treatment combination of 25 kg N ha^{-1}×1.5 kg B ha^{-1}(N_1B_2) which was statistically similar with $N_0B_{2,}$ $N_1B_{0,}N_1B_1$ and $N_2B_{0.}$ The lowest pod length (1.60cm) was found on interaction effect of without nitrogen × no boron application (N_0B_0) which was statistically similar with $N_2B_{1.}$

4.2.3 Effective pod plant^{-1} (no.)

Effect of nitrogen

The data on the number of effective pods $plant^{-1}$(Table 3) showed significant influence due to nitrogen. The maximum number of effective pod $plant^{-1}$(39.04) was observed in 25 kg ha^{-1} (N_1) which was statistically identical with 35 kg N ha^{-1} (N_2). The minimum effective pod $plant^{-1}$(6.25) was revealed from without nitrogen (N_0).

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Effect of boron

Number of effective pod $plant^{-1}$of chickpea at different days after sowing as influenced by boron are shown in table 4. The maximum number of effective pod $plant^{-1}$(40.96) was obtained from 1.5 kg ha^{-1} (B_2) boron application and the lowest effective pod $plant^{-1}$(33.98) was recorded at without boron application (B_0) which was statistically identical with 1.0 kg ha^{-1}(B_1).

Interaction effect of nitrogen and boron

Significant variation was noticed on effective pod $plant^{-1}$ at different days after sowing as influenced by interaction effect of nitrogen and boron (Table 5). The maximum number of effective pod plant^{-1} (44.66) was recorded in 25 kg ha^{-1}×1.5 kg ha^{-1} (N_1B_2) which was statistically identical with N_2B_2 . The lowest effective pod plant^{-1}(30.83) was found on interaction effect of without nitrogen × no boron application (N_0B_0) which was statistically similar with N_0B_1.

Table 4. Effect of boron on Branch plant^{-1} (no.), Pod length (cm), Effective pod plant^{-1} (no.) and Non effective pod plant^{-1} (no.) on chickpea

BORON	Branch plant^{-1} (no.)	Pod length (cm)	Effective pod plant^{-1} (no.)	Non effective pod plant^{-1} (no.)
B_0	17.51 b	1.64 c	33.98 b	6.75 a
B_1	19.33 ab	1.75 a	35.39 b	6.758 ab
B_2	21.17 a	1.71 ab	40.96 a	6.07 b
SE(±)	**0.9542**	**0.0630**	**1.0361**	**0.3206**
CV (%)	**8.67**	**7.64**	**5.98**	**10.51**

i) B_0 = No Boron (Control); ii) B_1 = 1.0 kg ha^{-1}; iii) B_2 = 1.5 kg ha^{-1}

4.2.4 Non effective pod plant^{-1} (no.)

Effect of nitrogen

The data regarding the number of non effective pod plant^{-1}(Table 3) exerted significant influence due to nitrogen. The maximum number of non effective pod plant^{-1}(6.84) was found in no nitrogen application (N_0).The minimum non effective pod plant^{-1}(6.25) was recorded in 35 kg N ha-^{1} (N_2) which was statistically similar with 25 kg ha^{-1} (N_1).

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Effect of boron

Number of non effective pod plant^{-1}of chickpea at different days after sowing as influenced by boron are shown in table 4. The maximum number of non effective pod plant^{-1}(6.75) was obtained fromwithout boron application (B_0) which was statistically similar with 1.0 kg ha^{-1}(B_1). The lowest non effective pod plant^{-1}(6.07) was recorded at 1.5 kg ha^{-1} (B_2) boron application which was statistically similar with 1.0 kg ha^{-1}(B_1).

Interaction effect of nitrogen and boron

Significant variation was noticed on non effective pod plant^{-1}at different days after sowing as influenced by interaction effect of nitrogen and boron (Table 5). The maximum number of non effective pod plant^{-1} **(**7.23) was remarked on treatment combination of without nitrogen × no boron application (N_0B_0) which was statistically identical with N_0B_1 and similar with all interaction except (N_1B_2). The lowest non effective pod plant^{-1}(5.73) was found on interaction effect of 25 kg ha^{-1}×1.5 kg ha^{-1}(N_1B_2) which was statistically similar with all interaction except N_0B_0 and N_0B_1.

Table 5. Interaction effect on nitrogen and boron of Branch plant^{-1} (no.), Pod length (cm), effective pod plant^{-1} (no.) and non effective pod plant^{-1} (no.) on chickpea

INTERACTION	Branch plant^{-1} (no.)	Pod length (cm)	Effective pod plant^{-1} (no.)	Non effective pod plant^{-1} (no.)
N_0B_0	16.19 c	1.60 cd	30.83 d	7.23 a
N_0B_1	17.29 bc	1.75 bc	32.66 cd	7.00 a
N_0B_2	19.32 a-c	1.86 ab	36.91 b	6.29 ab
N_1B_0	18.19 bc	1.81 a-c	35.15 bc	6.40 ab
N_1B_1	20.59 ab	1.90 ab	37.33 b	6.83 ab
N_1B_2	22.37 a	2.02 a	44.66 a	5.73 b
N_2B_0	18.17 bc	1.83 a-c	35.98 bc	6.12 ab
N_2B_1	20.12 ab	1.60 cd	36.20 bc	6.43 ab
N_2B_2	21.82 a	1.37 d	41.33 a	6.20 ab
SE(±)	**0.1091**	**0.1091**	**1.7946**	**0.5554**
CV (%)	**8.67**	**7.64**	**5.98**	**10.51**

i) N_0 = No nitrogen (Control); ii) N_1 = 25 kg ha^{-1}; iii) N_2 = 35 kg ha^{-1}

i) B_0 = No Boron (Control); ii) B_1 = 1.0 kg ha^{-1}; iii) B_2 = 1.5 kg ha^{-1}

4.2.5 Pod plant^{-1} (no.)

Effect of nitrogen

The data on the number of pod plant^{-1}(Figure 5) exerted significant influence due to nitrogen. The maximum number of pod plant^{-1}(45.35) was found in 25 kg ha^{-1} (N_1 which was statistically identical with 35 kg ha^{-1} (N_2). The minimum pod plant^{-1}(40.30) was revealed from without nitrogen (N_0).

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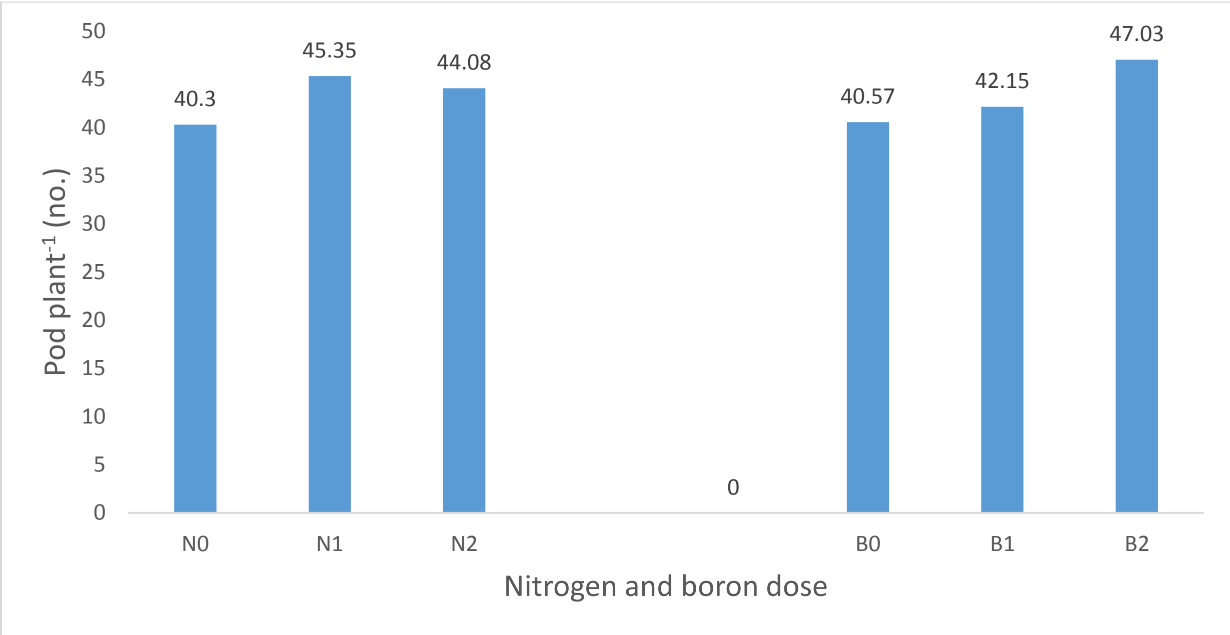
Effect of boron

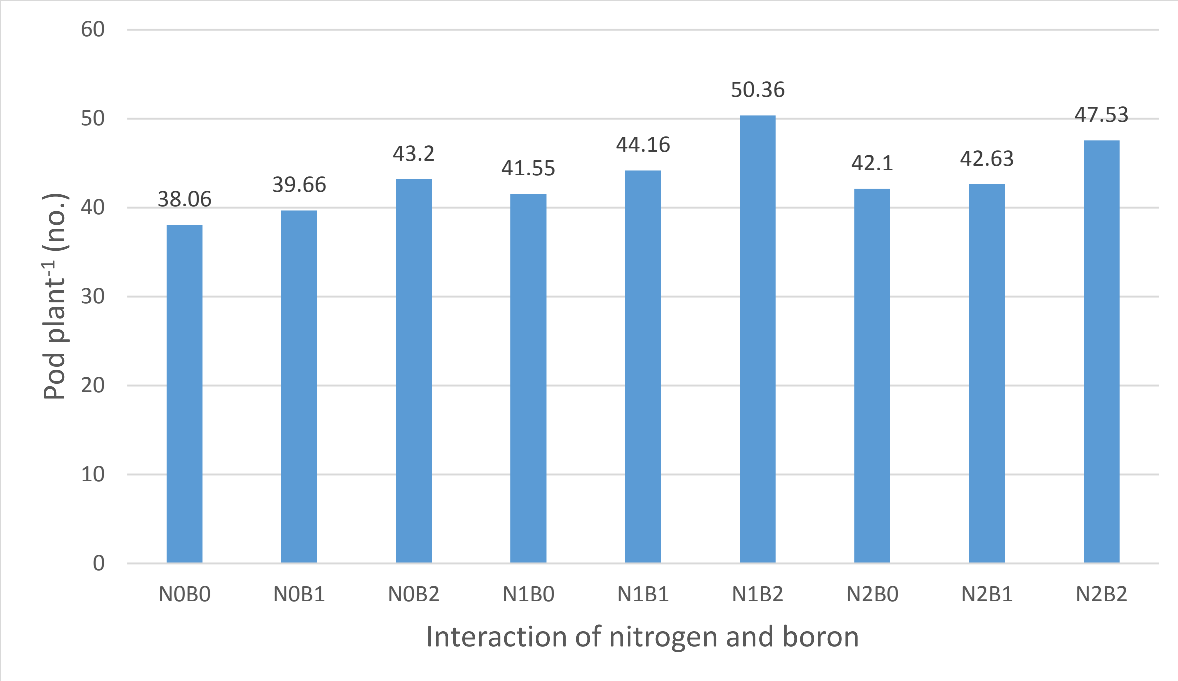
Number of pod plant^{-1}of chickpea at different days after sowing as influenced by boron are shown in Figure 5. The maximum number of pod plant^{-1}(47.03) was obtained from 1.5 kg ha^{-1} (B_2) boron application. The lowest pod plant^{-1}(40.57) was recorded at without boron application (B_0) which was statistically identical with 1.0 kg ha^{-1}(B_1).



i) N_0 = No nitrogen (Control); ii) N_1 = 25 kg ha^{-1}; iii) N_2 = 35 kg ha^{-1}

i) B_0 = No Boron (Control); ii) B_1 = 1.0 kg ha^{-1}; iii) B_2 = 1.5 kg ha^{-1}

Figure 5. Effect of nitrogen and boron on Pod plant^{-1} (no.)of chickpea (SE (±) = 1.5083)



i) N_0 = No nitrogen (Control); ii) N_1 = 25 kg ha^{-1}; iii) N_2 = 35 kg ha^{-1}

i) B_0 = No Boron (Control); ii) B_1 = 1.0 kg ha^{-1}; iii) B_2 = 1.5 kg ha^{-1}

Figure 6. Interaction effect of nitrogen and boron on Pod plant^{-1} (no.)of chickpea (SE (±) = 2.6124)

Interaction effect of nitrogen and boron

Significant variation was noticed on pod plant^{-1}at different days after sowing as influenced by interaction effect of nitrogen and boron (Figure 6). The maximum number of pod plant^{-1}(50.36) was exerted from the interaction of 25 kg N ha^{-1}×1.5 kg N ha^{-1}(N_1B_2) which was similar with N_2B_2. The lowest pod plant^{-1}(38.06) was found on interaction effect of without nitrogen × no boron application (N_0B_0) which was statistically similar with N_0B_1, N0B2, N_1B_0, N_2B_0 and N_2B_1.

4.2.6 Seeds pod^{-1}

Effect of nitrogen

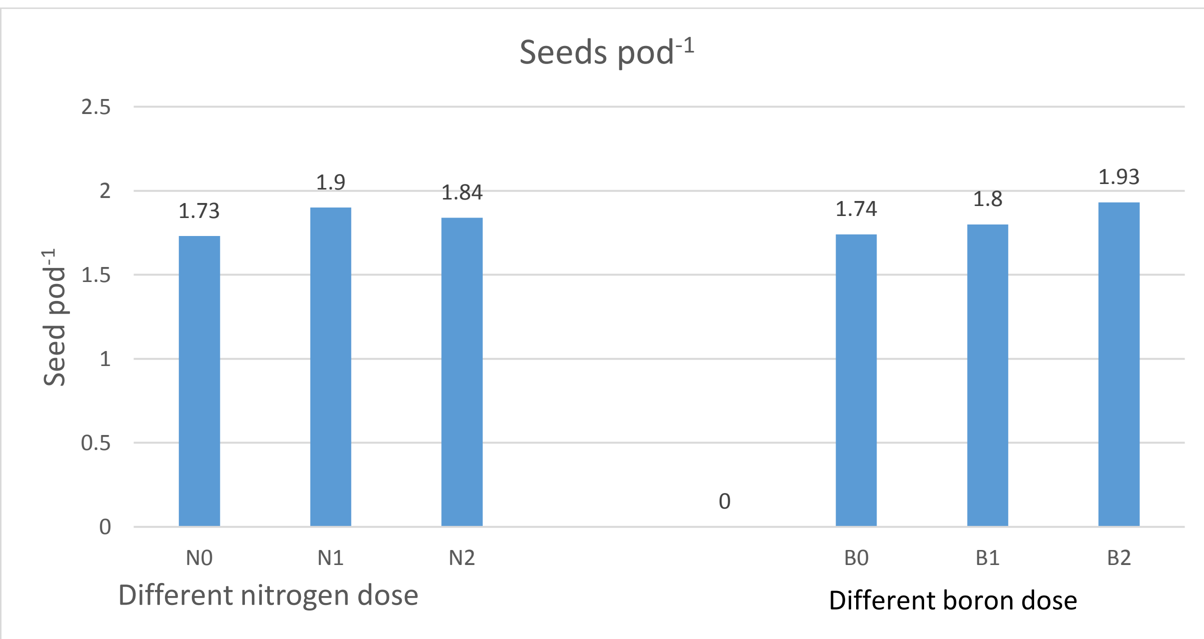
The data regarding the number of seed pod^{-1}(Figure 7) exerted significant influence due to nitrogen. The maximum number of seed pod^{-1}(1.90) was found in 25 kg N ha^{-1} (N_1 which was statistically similar with 35 kg N ha^{-1} (N_2). The minimum seed pod^{-1}(1.73) was revealed from without nitrogen (N_0) which was statistically similar with 35 kg N ha^{-1} (N_2).

Effect of boron

Number of seed pod^{-1} of chickpea at different days after sowing as influenced by boron are shown in (Figure 7). The maximum number of seed pod^{-1}(1.93) was obtained from 1.5 kg ha^{-1} (B_2) boron application which was statistically similar with 1.0 kg ha^{-1}(B_1). The lowest seed pod^{-1} (1.74) was recorded at without boron application (B_0) which was statistically similar with 1.0 kg ha^{-1} (B_1).

Interaction effect of nitrogen and boron

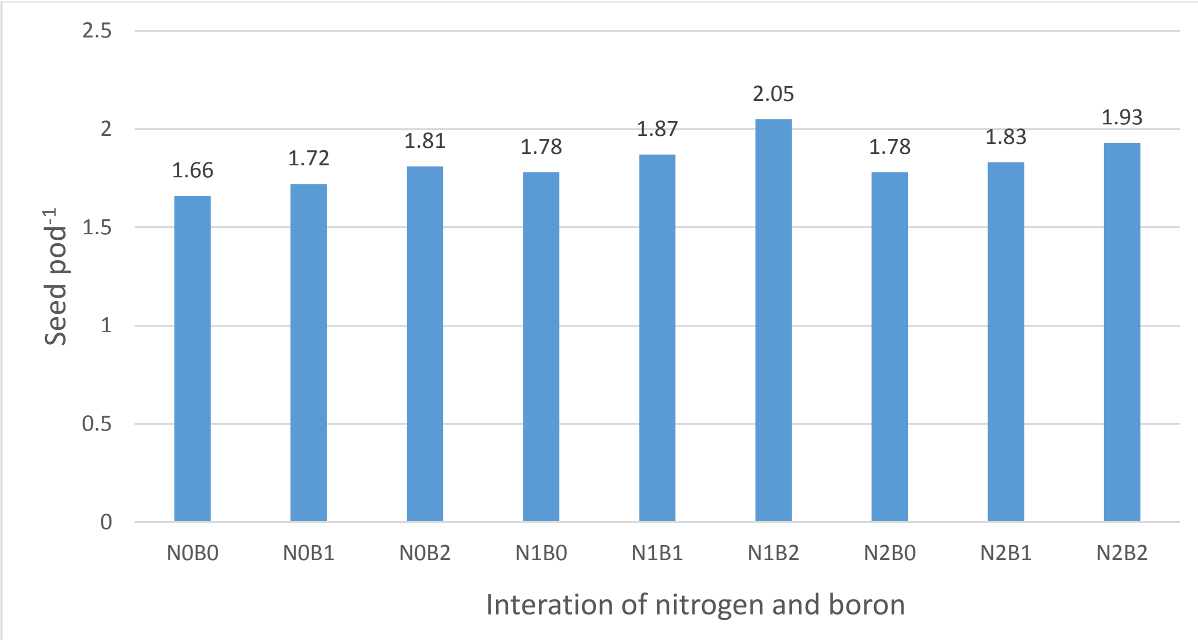
Significant variation was noticed on seed pod^{-1}at different days after sowing as influenced by interaction effect of nitrogen and boron (Figure 8). The maximum number of seed pod^{-1}(2.05) wasproduced by the treatment combination of 25 kg ha^{-1}×1.5 kg ha^{-1}(N_1B_2) which was statistically similar with N_0B_2, N_1B_1, $N_2B_1$and N_2B_2. The lowest seed pod^{-1}(1.66) was found on interaction effect of without nitrogen × no boron application (N_0B_0) which was statistically similar with N_0B_1,N_0B_2, N_1B_0,N_1B_0, N_1B_1 N_2B_0 and N_1B_0, N_2B_1.



i) N_0 = No nitrogen (Control); ii) N_1 = 25 kg ha^{-1}; iii) N_2 = 35 kg ha^{-1}

i) B_0 = No Boron (Control); ii) B_1 = 1.0 kg ha^{-1}; iii) B_2 = 1.5 kg ha^{-1}

Figure 7. Effect of nitrogen and boron on Seed pod^{-1}of chickpea (SE (±) = 0.0722)



i) N_0 = No nitrogen (Control); ii) N_1 = 25 kg ha^{-1}; iii) N_2 = 35 kg ha^{-1}

i) B_0 = No Boron (Control); ii) B_1 = 1.0 kg ha^{-1};iii) B_2 = 1.5 kg ha^{-1}

Figure 8. Interaction effect of boron on Seed pod^{-1}of chickpea (SE (±) = 0.1250)

4.2.7 1000-grain weight (g)

Effect of nitrogen

The data on1000-grain weight(Table 6) showed significant influence due to nitrogen. The maximum 1000-grain weight (151.64 g) was found in 25 kg ha^{-1} (N_1 which was statistically identical with 35 kg ha^{-1} (N_2). The minimum 1000-grain weight(142.17) was revealed from without nitrogen (N_0).

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Effect of boron

1000-grain weightof chickpea at different days after sowing as influenced by boron are shown in Table 7. The maximum 1000-grain weight[1](153.45g) was obtained from 1.5 kg ha^{-1} (B_2) boron application. The lowest 1000-grain weight(143.28g) was recorded at without boron application (B_0) which was statistically identical with 1.0 kg ha^{-1}(B_1).

Interaction effect of nitrogen and boron

Significant variation was noticed on 1000-grain weightat different days after sowing as influenced by interaction effect of nitrogen and boron (Table 8). The maximum 1000-grain weight(158.31g) wasrecorded on treatment combination of 25 kg ha^{-1}×1.5 kg ha^{-1}(N_1B_2) which was statistically similar with N_0B_2, N_1B_1, $N_2B_1$and N_2B_2. The lowest 1000-grain weight(137.31g) was found on interaction effect of without nitrogen × no boron application (N_0B_0) which was statistically similar with N_0B_1,N_1B_0 and N_2B_0.

4.2.8 Seed yield (t ha^{-1})

Effect of nitrogen

The data regarding the number of seed yield(Table 6) exerted significant influence due to nitrogen. The maximum seed yield (2.14 t ha^{-1}) was found in 25 kg N ha^{-1} (N_1) which was statistically identical with 35 kgN ha^{-1} (N_2). The minimum seed yield(1.86 t ha^{-1}) was revealed from without nitrogen (N_0).

Effect of boron

Data on grain seed of chickpea at different days after sowing as influenced by boron are shown in Table 7. The maximum seed yield(2.19 t ha^{-1}) was obtained from 1.5 kg ha^{-1} (B_2) boron application which was statistically similar with 1.0 kg ha^{-1}(B_1). The lowest seed yield(1.86 t ha^{-1}) was recorded at without boron application (B_0) which was statistically similar with 1.0 kg ha^{-1} (B_1). The results showed that boron significantly influenced and increased the seed yield over no boron application.

Table 6. Effect of nitrogen of 1000-grain weight (g),Grain yield(t ha^{-1}) and Straw yield (t ha^{-1})on chickpea

NITROGEN	1000-seed weight (g)	seed yield (t ha^{-1})	Stover yield (t ha^{-1})
N_0	142.17 b	1.86 b	2.04 b
N_1	151.64 a	2.14 a	2.31 a
N_2	150.26 a	2.06 a	2.25 ab
SE(±)	**2.8537**	**0.0887**	**0.1044**
CV (%)	**4.09**	**9.31**	**10.04**

i) N_0 = No nitrogen (Control); ii) N_1 = 25 kg ha^{-1}; iii) N_2 = 35 kg ha^{-1}

Interaction effect of nitrogen and boron

Significant variation was noticed on grain yieldat different days after sowing as influenced by interaction effect of nitrogen and boron (Table 8). The maximum seed yield(2.37 t ha^{-1}) was remarked on treatment combination of 25 kg N ha^{-1}×1.5 kg B ha^{-1}(N_1B_2) which was statistically similar with $N_1B_1$and N_2B_2. The lowest seed yield (1.72 t ha^{-1}) was found on interaction effect of without nitrogen × no boron application (N_0B_0) which was statistically similar with N_0B_1,N_0B_2, N_1B_0, N_2B_0 and N_2B_1.

4.2.9 Stover yield (t ha^{-1})

Effect of nitrogen

Effect of poultry manure

Stover yield exerted significant influence due to nitrogen (Table 6). The maximum stover yield (2.31t ha^{-1}) was found in 25 kg N ha^{-1} (N_1) which was statistically similar with 35 kg N ha^{-1} (N_2). The minimum stover yield (2.04 t ha^{-1}) was revealed from without nitrogen (N_0) which was statistically similar with 35 kg N ha^{-1} (N_2).

Effect of boron

Data on stover yield of chickpea at different days after sowing as influenced by boron are shown in table 7. The height stover yield (2.37 t ha^{-1}) was obtained from 1.5 kg ha^{-1} (B_2) boron application which was statistically similar with 1.0 kg ha^{-1}(B_1). The lowest stover yield (2.04 t ha^{-1}) was recorded at without boron application (B_0) which was statistically similar with 1.0 kg ha^{-1} (B_1) application.

Table 7. Effect of boron of 1000-seed weight (g),Grain yield(t ha^{-1}) and Straw yield (t ha^{-1}) on chickpea

BORON	1000-seedweight (g)	seed yield (t ha^{-1})	Stover yield (t ha^{-1})
B_0	143.28 b	1.86 b	2.04 b
B_1	147.34 b	2.01 ab	2.19 ab
B_2	153.45 a	2.19 a	2.37 a
SE(±)	**2.8537**	**0.0887**	**0.1044**
CV (%)	**4.09**	**9.31**	**10.04**

i) B_0 = No Boron (Control); ii) B_1 = 1.0 kg ha^{-1}; iii) B_2 = 1.5 kg ha^{-1}

Interaction effect of nitrogen and boron

Significant variation was noticed on stover yield at different days after sowing as influenced by interaction effect of nitrogen and boron (Table 8). The maximum stover yield(2.51 t ha^{-1}) was remarked on treatment combination of 25 kg ha^{-1}× 1.5 kg ha^{-1}(N_1B_2) which was statistically similar with N_0B_2, N_1B_1, N_2B0,. N_2B_1 and N_2B. The lowest stover yield(1.90 t ha^{-1}) was found on interaction effect of without nitrogen × no boron application (N_0B_0) which was statistically similar with N_0B_1,N_0B_2, N_1B_0, N_2B_0 and N_2B_0.

Table 8. Interaction effect of nitrogen and boron of 1000-grain weight (g),Grain yield ($t\ ha^{-1}$) and Straw yield ($t\ ha^{-1}$) on chickpea

INTERACTION	1000-seed weight (g)	seed yield ($t\ ha^{-1}$)	Stover yield ($t\ ha^{-1}$)
N_0B_0	137.31 d	1.72 d	1.90 c
N_0B_1	140.30 cd	1.89 c-d	2.05 bc
N_0B_2	148.90 a-c	1.98 b-d	2.17 a-c
N_1B_0	145.30 b-d	1.92 b-d	2.11 bc
N_1B_1	151.30 ab	2.13 a-c	2.32 ab
N_1B_2	158.31 a	2.37 a	2.51 a
N_2B_0	147.23 b-d	1.95 b-d	2.13 a-c
N_2B_1	150.41 a-c	2.01 b-d	2.22 a-c
N_2B_2	153.13 ab	2.23 ab	2.41 ab
SE(±)	**4.9428**	**0.1537**	**0.1808**
CV(%)	**4.09**	**9.31**	**10.04**

i) N_0 = No nitrogen (Control); ii) N_1 = 25 kg ha^{-1}; iii) N_2 = 35 kg ha^{-1}

i) B_0 = No Boron (Control); ii) B_1 = 1.0 kg ha^{-1}; iii) B_2 = 1.5 kg ha^{-1}

CHAPTER V

SUMMARY AND CONCLUSION

An experiment was carried out at experimental field of Sher-e- Bangla Agricultural University (SAU), Sher-e-Bangla nagar, Dhaka to evaluate the effect of nitrogen and boron on growth and yield of chickpea (*cice arietinum*L.*)*. The experiment comprised of two different factors *viz*. Factor A: Nitrogen fertilizer level-3;i) N_0 = No nitrogen (Control) ii) N_1 = 25 kg ha^{-1} and iii) N_2 = 35 kg ha^{-1} and factor B: Boron fertilizer level-3; i) B_0 = No Boron (Control) ii) B_1 = 1.0 kg ha^{-1} and iii) B_2 = 1.5 kg ha^{-1}. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replication. There were 9 treatment combination and total 27 plot. All the data recorded are subjected to statistical analysis using analytical computer software program statistix-10. The mean differences among the treatments were compared by least significant difference test at 5% level of significance.

The weather during the crop growing period did not exhibit any major fluctuations and was congenial for crop growth. A total rainfall of 302 mm was received in 27 rainy days during the investigation period, which was insufficient for rice crop. Hence, need based irrigations were given to avoid moisture stress.

The observation were recorded on Plant height (cm), plant dry weight (g), pod $plant^{-1}$, pod length (cm), number of pod $plant^{-1}$, number of effective pod $plant^{-1}$, number of non-effective pod $plant^{-1}$, number of seed pod^{-1}, 1000–seed weight, seed yield (t ha^{-1}), stover yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index (%)

The effect of nitrogen showed significantly variation on different growth and yield parameters among the different treatment. Considering growth parameters; application of nitrogen in 25 kg ha^{-1} (N_1) showed the highest plant (13.36, 33.54, 53.82, 57.08 and 69.46 cm at 25, 50, 75, 100 DAS and at harvest , respectively), plant dry weight weight (0.37, 2.63, 6.17, 11.19 and 10.95 g at 25, 50, 75, 100 DAS and at harvest, respectively) and the shortest plant (11.14, 30.19, 49.56 and 65.00 cm at 25, 50, 75 DAS and at harvest, respectively), plant dry weight (0.28, 1.78, 4.87, 9.43 and 9.28 g at 25, 50, 75, 100 DAS and at harvest, respectively was recorded from without nitrogen (N_0). Considering yield contributing characters; number of branch $plant^{-1}$ (20.38), pod length(1.91cm), effective pod plant^{-1}(39.04), pod plant^{-1}(45.35), seed pod^{-1}(1.90),1000-seed weight(151.64 g), seed yield (2.14 t ha^{-1}) and stover yield(2.31t ha^{-1}) was found in 25 kg ha^{-1} (N_1). The lowest number of branch plant^{-1} (17.60), pod length(1.60cm), effective pod plant^{-1} (6.25), pod plant^{-1} (40.30), seed pod^{-1}(1.73), 1000-seed weight(142.17), seed yield(1.86 t ha^{-1}) and stover yield (2.04 t ha^{-1}) was recorded from without nitrogen (N_0). In case of numberof non effective pod plant^{-1}(6.84) was recorded from without nitrogen (N_0)and the lowest value number of non effective pod plant^{-1}(6.25) was revealed from 25 kg ha^{-1} (N_1).

The effect of boron showed significantly variation on different growth and yield parameters among the different treatment. Considering growth parameters; 1.5 kg ha^{-1} (B_2) boron application showed the highest plant (13.98, 34.60, 55.06, 58.26 and 70.35 cm at 25, 50, 75, 100 DAS and at harvest, respectively), plant dry weight (0.37, 2.63, 6.17, 11.19 and 10.95 g at 25, 50, 75, 100 DAS and at harvest, respectively) and the shortest plant (11.21, 30.11, 49.62, 52.10 and 65.44 cm at 25, 50, 75, 100 DAS and at harvest respectively) plant dry weight (0.28, 1.78, 4.87, 9.43 and 9.28 g) was revealed from without nitrogen (N_0) at 25, 50, 75, 100 DAS and at harvest, respectively) was recorded from no boron application (B_0). Considering yield contributing characters; 1.5 kg ha^{-1} (B_2) boron application showed the branch plant^{-1}(21.17), height pod length(1.75cm), effective pod plant^{-1}(40.96), pod plant^{-1}(47.03), seed pod^{-1}(1.93), 1000-seed weight^{1}(153.45g), seed yield(2.19 t ha^{-1}) and stover yield(2.37 t ha^{-1}). The lowest branch plant^{-1} (17.51), pod length(1.64cm), effective pod plant^{-1}(33.98),pod plant^{-1} (40.57), seed pod^{-1} (1.74), 1000-grain weight (143.28g), seed yield (1.86 t ha^{-1}) and stover yield(2.04 t ha^{-1}) recorded from no boron application (B_0). In case of number of non effective pod plant^{-1}(6.75) was recorded from without boron application (B_0) and the lowest value number of non effective pod plant^{-1} (6.07) was revealed from 1.0 kg ha^{-1} (B_1).

Interaction effect of nitrogen and boronshowed significantly variation on different growth and yield parameters among the different treatment. N_1B_2 showed the heighest plant (15.30, 37.20, 58.77, 62.47 and 72.85 cm) at 25, 50, 75, 100 DAS and at harvest, respectively), plant dry weight (0.41, 2.73,6.99, 12.34 and 12.11 g at 25, 50, 75, 100 DAS and at harvest, respectively), branch plant^{-1}(25.17), branch plant^{-1}(22.37), pod length (2.02cm), effective pod plant^{-1} (44.66), pod plant^{-1}(50.36), seed pod^{-1}(2.05), 1000-seed weight(158.31g), seed yield (2.37 t ha^{-1}) and stover yield (2.51 t ha^{-1}). The lowest plant (10.32, 29.31, 47.50, 49.97 and 62.70 cm at 25, 50, 75, 100

DAS and at harvest, respectively), plant dry weight (0.23, 1.19, 4.10, 8.38 and 8.10 g) at 25, 50, 75, 100 DAS and at harvest, respectively), branch plant^{-1}(16.19), pod length(1.60cm), effective pod plant^{-1}(30.83), pod plant^{-1}(38.06), seed pod^{-1}(1.66), 1000-seed weight(137.31g), seed yield(1.72 t ha^{-1}) and stover yield(1.90 t ha^{-1}) was found from N_0B_0. In case of number of non effective pod plant^{-1} **(**7.23) was recorded from of without nitrogen × no boron application (N_0B_0) and the lowest value number of non effective pod plant^{-1}(5.73) was revealed from 25 kg ha^{-1}×1.5 kg ha^{-1} (N_1B_2)

From the above result it may be concluded that the combination of N_1B_2 i.e., 25 kg N ha^{-1}× 1.5 kg B ha^{-1}is optimum for the maximum growth and yield of chickpea compared to other treatment combinations. Under the consideration of the findings of this experiment, further studies may be suggested in different regions of Bangladesh for regional adaptability.

Recommendations:

To reach a specific conclusion and recommendations, more research work regarding this issue on chickpea should be done in different agro-ecological zones of Bangladesh with thus treatment variable.

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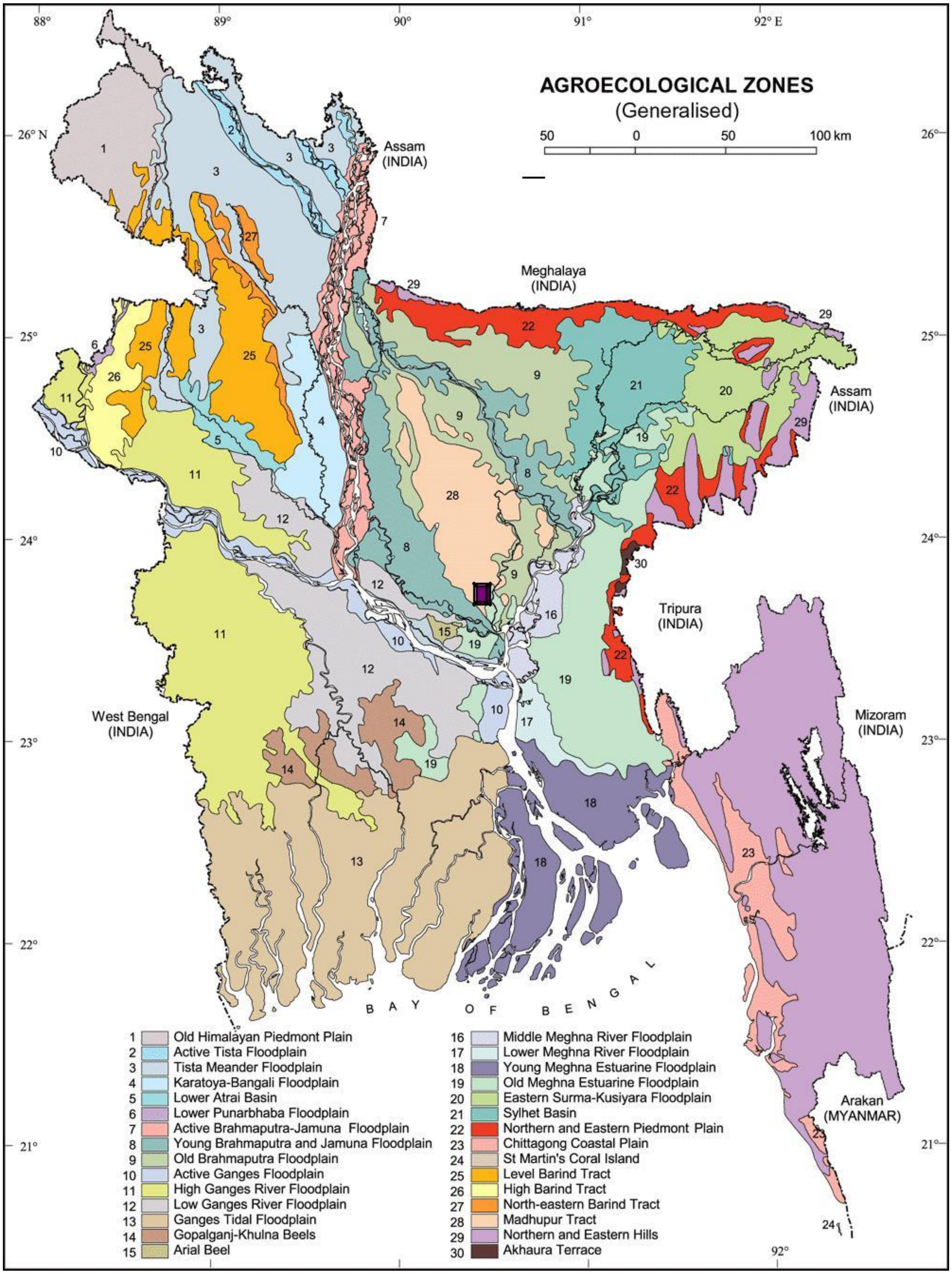
APPENDICES

Appendix I. Map showing the experimental sites under study



Appendix II: Monthly record of air temperature, rainfall, and relative humidity during the period fromNovember 2018 to april , 2019

Month	RH (%)	Air temperature (C)			Rainfall (mm)
		Max.	Min.	Mean	
November	65	32.0	19.0	26.0	35
December	74	29	15	22	15
January	68	26	10	18	7
February	57	15	24	25.42	25
March	57	34	16	28	65
April	66	35	20	28	155

Source: Bangladesh Meterological Department (Climatic Division), Agargaon, Dhaka-1207

Appendix III. Morphophysiological and chemical characteristics of experimental soil

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agronomy Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Not Applicable

Source: Soil Resource Development Institute (SRDI), Farmgate, Dhaka.

B. Physical and chemical properties of the initial soil

Characteristics	Value
Partical size analysis % Sand	27
%Silt	43
% Clay	30
Textural class	Silty Clay Loam (ISSS)
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20
Exchangeable K (me/100 g soil)	0.1
Available S (ppm)	0.45
Available B (ppm)	0.36

Source: Soil Resource Development Institute (SRDI), Farmgate, Dhaka.

Appendix IV. Some pictorial view of my reaserch work